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TECHNOLOGY APPLICATION CENTER
THE UNIVERSITY OF NEW MEXICO
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HEAT PIPE TECHNOLOGY

A BIBLIOGRAPHY WITH ABSTRACTS

QUARTERLY UPDATE

JULY-SEPTEMBER 1978

ASSEMBLED BY

THE HEAT PIPE INFORMATION OFFICE

OF

THE TECHNOLOGY APPLICATION CENTER
INSTITUTE FOR APPLIED RESEARCH SERVICES
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ALBUQUERQUE, NEW MEXICO

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INTRODUCTION

This is the third quarterly update for 1978 in the Heat Pipe Technology Bibliographic series.

This quarter has seen increased activity in all areas. This was due primarily to the large number of papers presented at the Third International Heat Pipe Conference held in Palo Alto, California, May 22-24, 1978. Several new publications are included under the category "General Applications." There is considerable activity in heat pipe applications for the aerospace industry, and with the need for verification of theory, heat pipe testing and operation also continues to be an active area of interest.

A library containing some of the articles and publications referenced in this bibliographic series has been established and the Center will, on a cost-recovery basis, aid readers to obtain copies of any cited material. Although a considerable effort has been made to insure that the bibliography is complete, readers are encouraged to bring any omissions to the attention of this Center.

Darryl L. Noreen
Editor

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A number of features have been incorporated to help the reader use this document. They consist of:

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I. GENERAL INFORMATION, REVIEWS, SURVEYS

HP78 10009 INTERNATIONAL HEAT PIPE CONFERENCE, 3RD, PALO ALTO, CA, May 22-24, 1978, Technical Papers, Members, $45; Nonmembers, $50

444 p., 1978, Conf. spons. by AIAA, Inc., New York, NY
Avail:AIAA

The development of an axially grooved heat pipe with nonconstant groove width is considered along with a variable conductance heat pipe for terrestrial applications, experiments with gravity-assisted heat pipes with and without circumferential grooves, the supersonic flow of vapor in the condensation zone of high temperature heat pipes, numerical calculations on the vapor flow in a flat-plate heat pipe with asymmetrical boundary conditions, entrainment limits in heat pipes, the dry-out limits of gravity assist heat pipes with capillary flow, the performance evaluation of gravity-assisted copper-water heat pipes with liquid overfill, and emerging heat pipe applications. Attention is also given to heat pipe mirrors for high power lasers, a sodium vapor heat pipe laser cell, technical applications of heat pipes in the low and high-temperature range, compatibility tests of various heat pipe working fluids and structural materials at different temperatures, a gas-controlled thermostat, the investigation of a cryogenic thermal diode, the reliability of low-cost liquid metal heat pipes, and a thermal canister experiment for the space shuttle.

HP78 10010 3RD INTERNATIONAL HEAT PIPE CONFERENCE, ABSTRACTS OF PAPERS

8 p., May 22-24, 1978, Palo Alto, CA
Avail:TAC

The abstracts of the papers presented during the 13 sessions of this 3rd Annual International Heat Pipe Conference are presented in this summary. The subjects covered include heat pipe performance limits, terrestrial applications, evaporation and condensation, gas-loaded heat pipes, cryogenic heat pipes, space applications, cooling of electrical components, and liquid metal heat pipes.

HP78 10011 2ND AIAA/ASME THERMOPHYSICS AND HEAT TRANSFER CONFERENCE, ABSTRACTS OF PAPERS

16 p., May 24-26, 1978, Palo Alto, CA
Avail:TAC

The abstracts of the papers presented during the 24 sessions of this 2nd Annual AIAA/ASME Thermophysics and Heat Transfer Conference are presented in this summary. A broad range of subjects is covered, including heat pipes.

HP78 10017 HEAT PIPE: A NEW TECHNOLOGY COMES OF AGE

Ranken, W.A., LASL, Los Alamos, NM, Energy, Stamford, CT, V 2:28-30, N4, 2 refs, Fall 1977

The device makes use of a working fluid whose latent heat of evaporation is transferred from a heat source to a heat-utilizing medium by means of an evaporation-condensation cycle. Condensed liquid is returned to the heat source (the heat pipe evaporator) by a self-contained pumping mechanism. Heat pipes have been constructed with an equivalent thermal conductance more than ten thousand times greater than copper. Heat pipes can be constructed to serve such functions as precision temperature control, one-way transmission of heat (thermal diode), and heat flux amplification or diminution. The working fluids that can be used to achieve these effects range from liquid hydrogen for cryogenic temperatures to silver and copper at very high temperatures. Approximately 75 percent of the current market for heat pipe energy recovery units is for HVAC systems for buildings where their use substantially reduces fuel requirements for heating in winter and reduces power requirements for air conditioning during summer. The remaining 25 percent of the market lies in industrial processing application. In addition to their role in energy conservation, heat pipes appear promising for the primary gasifier unit (methanator) in coal gasification. This proposed application is considered in some detail.

HP78 10013 HEAT PIPES, Volume 3, March 1976-March 1978, (Citations From The NTIS Data Base)

Reed, W., Rept. Supersedes NTIS/PS-77/0275, NTIS/PS-76/0249, NTIS/PS-75/317, V 1, 1964-72, NTIS/PS-76/0248, V 2, 1973-Feb. 1976, NTIS/PS-77/0274
Avail:NTIS

Theory, design, fabrication, testing, and operation of heat pipes are presented in these federally sponsored research reports. Applications are described in the areas of heating and air conditioning, power generation, electronics cooling, spacecraft, nuclear reactors, cooling engines, and thermodynamics. (This updated bibliography contains 170 abstracts, 33 of which are new entries to the previous edition.)

HP78 10014 HEAT PIPES, Volume 3, April 1977-March 1978, (Citations From the Engng. Data Base)

Reed, W., Rept. supersedes NTIS/PS-77/0276, NTIS/PS-76/0251, V 1, 1970-73, NTIS/PS-76/0250, V 2, 1974-March 1977, NTIS/PS-78/0303 185 p., 1978
Avail:NTIS

Research reports covering the thermodynamics, design, fabrication, and applications of heat pipes are cited from worldwide literature. Applications are described in the areas of electronics cooling, spacecraft thermal control, heat exchangers, heating and refrigeration, and waste heat utilization. (This updated bibliography contains 178 abstracts, all of which are new entries to the previous edition.)

HP78 10015 HEAT PIPES, Volume 2, 1974-March 1977, (Citations From The Engng. Data Base)

Reed, W., Rept. V 1, 1970-73, NTIS/PS-76/0250 223 p., 1978
Avail:NTIS

Research reports covering the thermodynamics, design, fabrication, and applications of heat pipes are cited from worldwide literature. Applications are described in the areas of electronics cooling, spacecraft thermal control, heat exchangers, heating and refrigeration, and waste heat utilization. (This updated bibliography contains 216 abstracts, none of which are new entries to the previous edition.)

II. HEAT PIPE APPLICATIONS

II. A. GENERAL APPLICATIONS

HP78 20007 NOVEL HEAT PIPE COMBINATION

Arcella, F.G., US Patent no. 4,067,237, Jan. 10, 1978

The basic heat pipe principle is employed in a heat pipe combination wherein two heat pipes are combined in opposing relationship to form an integral unit such that the temperature, heat flow, thermal characteristics, and temperature-related parameters of a monitored environment or object exposed to one end of the heat pipe combination can be measured and controlled by controlling the heat flow of the opposite end of the heat pipe combination.

HP78 20008 EMERGING HEAT PIPE APPLICATIONS

Basuilis, A., Formiller, D.J., (Hughes Aircraft Co., Torrance, CA), 3rd Int. Heat Pipe Conf. Tech. Papers, p. 59-62, May 22-24, 1978, Palo Alto, CA, AIAA, Inc., New York, NY, A78-35585
Avail:AIAA

The article discusses the application of heat pipes in various industrial, military, and space projects. Several types of heat pipes are described, including simple cylindrical heat pipes, switching heat pipes, thermal diodes, variable conductance heat pipes, and vapor chambers. Potential future applications of heat pipes are identified in the fields of electronics, spacecraft thermal control, heat pipe recovery systems, and missile applications.

HP78 20009 TECHNICAL APPLICATIONS OF HEAT PIPES

Brost, O., Groll, M., Muenzel, W.D., (Stuttgart Universitaet, Stuttgart, W. Germany), 3rd Int. Heat Pipe Conf. Tech. Papers, p. 80-87, May 22-24, 1978, Palo Alto, CA, AIAA, Inc., New York, NY, A78-35589
Avail:AIAA

Heat pipes have been developed to prototype and series-production level for various commercial applications. The low-temperature applications comprise high-performance fixed conductance and variable conductance heat pipes, and heat pipe diodes for spacecraft thermal control; gravity-assisted heat pipes for plastic fiber processing; heat pipes for cooling of electric motors and high-power semi-conductor devices; axial groove heat pipes for waste heat recovery units. The high-temperature applications comprise annular alkali-metal heat pipes as isothermal inserts for tubular furnaces, as black-body radiators, and as pyrolysis-cleaning furnaces; heat pipe heat transport system for Stirling engines.

HP78 20010 HEAT TRANSFER DEVICE

Brost, O., Schubert, P., Groll, M., Zimmerman, P., German (FRG) Patent 2,350,980, April 17, 1975, In German

The invention deals with an improvement of the heat transfer device known as "heat tube" where, independent of the direction of the heat flux, very exact stabilizing of the operational temperature is possible. It is proposed that a connecting pipe originating in the gas reservoir passes through the chamber and is provided with openings in the range of the cooling and heating zone. This connecting pipe and the gas reservoir have capillary structures along their inner walls which are connected with each other and with the chamber. Advantageously, the connecting pipe is additionally enclosed by a jacket.

HP78 20011 THE ABSOLUTE PHOTOABSORPTION CROSS-SECTION OF ATOMIC SODIUM IN THE REGION ABOVE THE 2P THRESHOLD (45-250 EV)

Codling, K., Hamley, J.R., West, J.B., (J.J. Thompson Phys. Lab. Univ. of Reading, Reading, England), J. Phys. B., V 10:2797-2807, 1977

No abstract available

HP78 20012 ALASKA LINE DEVELOPS NEW TECHNOLOGY

Congram, G.E., Oil Gas J., V 75:95-96, 101-102, 104, 109-111, N43, Nov 21, 1977

Significant developments and techniques used in the design and construction of the Trans-Alaska Pipeline are highlighted. Some of these methods were used to insure structural integrity of the pipeline and its necessary supporting equipment. Others were designed to protect both the pipeline and the Alaskan frontier environment and its inhabitants. Special considerations were given to heat pipes to maintain permafrost in a stable condition, cathodic protection to prevent corrosion, and installation of gate and check valves for assuring the operating integrity and protection of natural resources and the environment.

HP78 20013 PREVENTION OF PREFERENTIAL BRIDGE ICING USING HEAT PIPES, Executive Summary, Aug. 1975-Sept. 1976

Ferrara, A., Yenetchi, G., (Grumman Aerospace Corp., Bethpage, NY), Sept. 1976

This report describes the results of a 27-month analytical and test program to investigate the use of heat pipes and renewable energy sources (specifically earth heat) to avoid the preferential freezing of highway bridge decks. Based on computer simulations of typical preferential icing events (days), a single-system design is recommended for most US locations. This design consists of nominal 0.5-in heat pipes at the slab mid-plane, on 23-cm centers, connected to nominal two-in heat pipes in the ground via a pumped fluid loop, with one m of earth heat pipe provided for every 0.3 m^2 of bridge deck. The report also provides preliminary assessment of the design requirements and costs of an alternate solar collector design. It concludes that the solar collector design may offer economic advantages over the earth heat pipe system, and thus should be investigated further.

HP78 20014 AN INVESTIGATION OF ELECTROHYDRODYNAMIC HEAT PIPES

Loehrke, R.I., (Dept. Mech. Engng., Colorado State Univ., Fort Collins, CO), Sci. Tech. Aerosp. Rept. V 15:51, N13, 1977, Abstract no. N77-22422

No abstract available

HP78 20015 HEAT PIPES AND THEIR APPLICATIONS

Marinet, J., (Univ. de Poitiers, Poitiers, France), Rev. Gen. Therm., V 16:865-880, N192, 6 refs, Dec. 1977, In French with English abstract

The practical aspects of heat pipes for construction of heat exchangers are reviewed.

HP78 20016 DEVELOPMENT OF AN OSMOTIC HEAT PIPE

Minning, C.P., Biants, T.W., Fleishman, G.L., (Hughes Aircraft Co., Electro Optical and Data Systems Group, Culver City, CA), (Hughes Aircraft Co., Electron Dynamics Div., Torrance, CA), 3rd Int. Heat Pipe Conf. Tech. Papers, p. 327-334, May 22-24, 1978, AIAA, New York, NY Avail:AIAA

The osmotic heat pipe differs from a conventional heat pipe in that a semi-permeable membrane, instead of a capillary wick, is used to pump liquid from the condenser to the evaporator. Basic performance characteristics, membrane materials, and some problem areas in the design of these new devices are described in detail. An experimental apparatus has been designed and built to measure solvent permeation rates, as well as membrane semi-permeability. Test results are presented for two membrane samples using an aqueous sucrose solution.

HP78 20017 DEMAND SENSITIVE ENERGY STORAGE IN MOLTEN SALTS

Nemecek, J.J., Simmons, D.E., Chubb, T.A., (E.O. Hulburt Center for Space Res., Naval Res. Lab., Washington, D.C.), Solar Energy, V 20:213-217, N3, 5 refs, 1978

Heat-of-fusion energy storage and on-demand steam are obtained using heat pipe techniques to transfer heat to and from stacked salt cans and onto boiler tubes with a sealed "energy storage boiler" tank.

HP78 20018 HEAT PIPES: A NEW DIECASTING AID

Reay, D.A., (Int. Res. and Dev., Ltd.), Chart Mech. Engng., V 25:59,61-62, N2, Feb. 1978

The heat pipe has for several years been the subject of discussion in papers on pressure diecasting and a number of "ad hoc" tests have been carried out on its use as an aid to die cooling. The article discusses research carried out in England to investigate such applications. It covers selection of working fluids, performance capability, life of heat pipes, and their location in dies.

HP78 20019 CPI NICHE FOR HEAT PIPES?

Ricci, L.J., Chem. Engng., New York, NY, V 85:84-86, N2, Jan. 16, 1978

This paper is concerned with design and applications in the chemical industry of heat pipes, which long limited to electronics and ventilating roles, are now taking on process and boiler applications. Most CPI firms that have tested the devices recently for waste-heat recovery have been pleased. Design and operational details of a heat-pipe primer are given. In operation, a working fluid saturates a wick that lines the walls of a sealed evacuated chamber. When heat is absorbed at one end of the device, it evaporates liquid from the wick, producing a local pressure buildup. The vapor then flows to the cooler section of the container, where it condenses, surrendering its latent heat. The wick's capillary action (sometimes aided by gravity) returns the liquid to the hot end to restart the cycle. Regardless of heat-source temperature variations, the unit operates isothermally.

HP78 20020 ENERGY STORAGE AND TRANSMISSION BY CHEMICAL HEAT PIPE

Vakil, H.B., (GE Co., Schenectady, NY), 1977

A chemical heat pipe (CHP) is a concept of transporting and storing high grade thermal energy by the use of reversible exothermic/endothermic chemical reactions. It embraces three major areas of energy management: energy transmission, storage, and conservation. The importance of these three areas stems from the projected shortages of prime fossil fuels, the desire to substitute oil and gas by coal and nuclear energy, and the necessity of minimizing foreign oil imports required to make up the energy deficit. The scheme is examined in detail with emphasis on the $CH_4 + H_2O \rightleftarrows CO + 3H_2$ and $C_6H_6 + 3H_2 \rightleftarrows C_6H_{12}$ reactions.

HP78 20021 HEAT PIPES AND THEIR USE IN TECHNOLOGY

Vasilyev, L., (NASA, Washington, D.C.), Inzh. Fiz. Zh., USSR, V 31:905-907, N5, Nov. 1976, N78-18357/1SL

Heat pipes may be employed as temperature regulators, heat diodes, transformers, storage batteries, or utilized for transforming thermal energy into mechanical, electric, or other forms of energy. General concepts were established for the analysis of the transfer process in heat pipes. A system of equations was developed to describe the thermodynamics of steam passage through a cross-section of a heat pipe.

II. B. ENERGY CONVERSION

HP78 21010 OPTIMIZING A LOW-COST SATELLITE ENERGY SYSTEM

Drummond, J.E., (Maxwell Labs., Inc., San Diego, CA), Proc. of 12th Intersoc. Energy Conversion Engng. Conf., V 2, 1977, Am. Nuclear Soc., Inc., La Grange Park, IL

The potential advantages of proposed geostationary power satellites frustrated by probably ionospheric damage and high cost encouraged the derivation and now the optimization of a modified satellite power system using lower, sun-synchronous orbits designed to minimize the limitations while avoiding creation of comparable new limitations. The previously proposed iso-insolation power satellite (IPS) system would, among other things, eliminate localized enhancement of electron density in the ionosphere arising from and deflecting microwave transmission from power satellites, introduce a new satellite form which appears to be an improvement on current designs, significantly reduce power converter mass through utilization of a ferroelectric heat engine, and greatly reduce the size and weight of both the transmitting and receiving antennas due to the much shorter microwave link. It appears that a relatively simple derivative of the space shuttle could be used to implement the IPS system, and that, once implemented, such a system could provide power continuously worldwide at a cost significantly lower than fossil or nuclear power. A condition on the system's economy is that it must have load centers distributed throughout the world including the oceans where hydrogen could be produced for mobile vehicle use.

HP78 21011 SPACE SOLAR POWER STATIONS

Vanke, V.A., Lopukhin, V.M., Savvin, V., (Moskovskii Gosudarstvennyi Universitet, Moscow, USSR), Uspekhi Fizicheskikh Nauk, V 123:633-655, Dec. 1977, In Russian, A78-27442

The paper surveys the current status of studies on solar power stations in geosynchronous orbit, which would convert solar energy into electric power and transmit it to earth by microwave. Basic schemes for such a system are presented, economic estimates are made, and the prospects for developing orbiting solar power stations are discussed.

II. C. ENERGY CONSERVATION, SOLAR, NUCLEAR, AND OTHER ENERGY SYSTEMS

HP78 22038 PROCEEDINGS OF THE ERDA WORKSHOP ON FLUID WASTE HEAT RECOVERY AND UTILIZATION, 1977

Anon., (Washington Sci. Mark, Inc., Washington, D.C.), Proc. of ERDA Workshop on Fluid Waste Heat Recovery and Utilization, Washington, D.C., 127 p., Nov. 17-19, 1976, ERDA, Div. of Ind. Energy Conserv., Washington, D.C., by Washington Sci. Mark, Inc., Washington, D.C.
Avail: NTIS

The objective of this workshop was to develop specific ideas for research, development and demonstration relating to the utilization of fluid waste streams in the temperature range of 100° to 200° F, which are generated by industrial processes. The participants were industrial engineers, executives, and researchers knowledgeable of the thermodynamic processes within their various sectors. Joining them were technologists specializing in concepts which could be utilized for fluid waste heat augmentation. These areas of expertise included heat exchangers, heat pumps, heat pipes, and solar utilization techniques. Ninety-three specific research and development ideas were formulated by the participants. Each of these projects was evaluated by the groups in terms of energy conservation potential, time and money required for RD&D, and probability of implementation. A description of the recommendations generated during the workshop is contained in the final appendix.

HP78 22039 ENERGY STORAGE: USER NEEDS AND TECHNOLOGY APPLICATIONS, CONF. PROC., 1976

Anon., User Needs and Tech. Appl. Conf. Proc., Pacific Grove, CA, 424 p., Feb. 8-13, 1976, Tech. Info. Center, Oak Ridge, TN, CONF-760212, Publ. ERDA, 1977
Avail:NTIS

Proceedings include 21 papers on industrial needs for energy storage and the development of new energy storage technologies. Among the topics discussed are energy storage for economical load management by electric utilities, optimization of energy storage facilities of electric power systems, financial barriers to the widespread introduction of residential-type energy-saving heating and cooling equipment. the attitude of environmentalists toward energy storage, the advantages and potential of batteries for energy storage, a progress report on the use of hydrogen for energy storage by electric utilities, energy storage and transmission by chemical heat pipes, surface and underground pumped-hydro storage and compressed-air storage systems, thermal energy storage in phase change materials and in reversible chemical reactions, and flywheel and superconducting magnetic energy storage systems.

HP78 22040 SUN BUCKET MARK IV

Anon., (Mann-Russell Electronics, Inc.)

A sun-tracking solar collector using Si-solar cell power supply is described.

HP78 22041 RESEARCH APPLIED TO SOLAR-THERMAL POWER SYSTEMS

(Minnesota Univ., Minneapolis, MN), (Honeywell, Inc., Minneapolis, MN), 1974

Photographs, diagrams, tables, and graphs are presented on various aspects of solar collectors, reflector life tests, heat pipes, solar absorber coatings, cost analysis of transfer loop systems, cooldown of absorber tubes, thermal conductivity of insulation, and thermal storage.

HP78 22042 HEAT STORE FOR SOLAR ENERGY UTILIZATION IN HEATING SYSTEMS AND WATER HEATING

Abhat, A., (Stuttgart Univ., (TH), Germany, F.R., Inst. Fuer Kernenergetik und Energiesysteme), May 1977, In German
Avail:NTIS

After a survey of the main parameters for heat store construction, a new latent-heat store concept is described which takes account of the experience with stores in existing solar houses. The new concept is based on a modular construction. Each module has a finned heat pipe partitioned into three compartments (store space, heat source region, and heat sink region). The space between the fins is filled with a storage material which changes from the solid to the liquid phase when heat is added. The test model was operated with paraffin and wax ester. Finally, a proposal is made for an integration of the latent-heat store concept into a solar space and water heating system.

HP78 22043 CCMS SOLAR ENERGY PILOT STUDY: REPORT OF THE ANNUAL MEETING

Allen, R.W.; Blum, S.; Univ. of Maryland, College Park, MD, Dept. of Mech. Engng., CCMS Solar Energy Pilot Study Meeting, Copenhagen, Denmark, Sept. 13, 1976, 22 p.

Sixteen of the nineteen participating countries, plus the European communities, presented their national programs or summarized their country's present activities in solar heating and cooling systems in buildings. Solar heating and cooling programs are summarized for: Australia, Belgium, Canada, Denmark, Federal Republic of Germany, France, Greece, Iran, Israel, Italy, Jamaica, Monaco, the Netherlands, Saudi Arabia, Spain, Sweden, Turkey, USA, and the European communities. Summaries of the 1976 special format reports are presented. Australian performance data on three domestic hot water systems operating at system solar efficiencies of up to 25 percent are reported. A Canadian interim format report summarizes the status of an annual solar heat storage system and combined solar heating and heat pump system. The performance of the zero energy house is described in the Danish report. The status of projects in heat pipes and solar tap water heating is described in the Federal Republic of Germany summary. The summary report of France concerns the thermal performance of the glazed solar heated masonry walls (Trombe wall) in an experimental dwelling at Odeillo. A subsystem report covering the performance of a reflecting horizontal collector is presented by Greece. Sweden summarizes the performance or projected performance of three dwellings. The United States summary covers the performance of seven systems, including two solar heated schools, one solar heated and cooled school, a solar heated and cooled residence, a combined solar heating and heat pump residential system, an apartment domestic hot water system, and a large shallow solar pond for supplying industrial process hot water. Projects for which special format reports will be prepared during 1977 are reviewed.

HP78 22044 A GREENHOUSE SOLAR DISTILLATION UNIT COMBINED WITH HEAT PIPES (UNSTEADY-STATE CONDITIONS)

Bairamov, R.B., Toiliev, K., Mukhammetdurdyeva, O., Int. Chem. Engng., V 15:454-456, N3, July 1975

No abstract available

HP78 22045 HEAT PIPES IN FLAT-PLATE SOLAR COLLECTORS

Bienert, W.B., Wolf, D.A., (ASME, Solar Energy Div.), Presented at Winter Annual Mtg. of ASME, New York, NY, 11 p., Dec. 5, 1976

No abstract available

HP78 22046 APPLICATION OF CHEMICAL ENGINEERING TO LARGE SCALE SOLAR ENERGY

Chubb, T., Nemecek, J.J., Simmons, D.E., (E.O. Hulbert Center for Space Res., Naval Res. Lab., Washington, D.C.), Solar Energy, V 20:219-224, N3, 5 refs, 1978

In the Solchem concept, sunlight is converted to chemical energy in disbursed solar furnaces. Products are piped to a central station where energy is stored as latent heat-of-fusion in a eutectic salt. Heat pipe boilers provide on-demand power plant steam.

HP78 22047 DEVELOPMENT OF A PASSIVE HEATING AND COOLING SYSTEM USING A PUMPED HEAT PIPE, First Quarterly Technical Progress Report, Sept. 6-Nov. 30, 1977

Dieckmann, J.T., (Foster-Miller Assoc., Inc., Waltham, MA), Dec. 1977
Avail:NTIS

The technical progress in the program versus schedule and budget is summarized. The efforts expended on each task are discussed briefly.

HP78 22048 MINIATURE SOLAR-ELECTRIC POWER SYSTEM

Drummond, J., (Maxwell Labs., Inc., San Diego, CA), Proc. of 12th Intersoc. Energy Conversion Engng. Conf., V 2, 1977, American Nuclear Society, Inc., La Grange Park, IL

The large thermal energy fluxes which can be carried by heat pipes make possible a thermal-to-electrical power converter of compact design. One such system which has been designed would consist of 22 stages of ferroelectric heat engines, each employing nearly-Carnot cycles and 23 intervening electrically actuated heat pipes. Each stage would be only 30 micro-meters thick; each heat pipe only 1.7 cm long. A kW converter would fit inside a box 20 cm^2 x 45 cm high. It would weigh only 3 kg and would pay back the energy required for mining, refining, and combining the materials of which it is constructed in 22 days at a quarter of its peak power output. Application in a home solar-electric and heating system is illustrated.

HP78 22049 DEVICE FOR GAS GENERATION

Duerrfeld, R., Van Heek, K.H., Bittighofer, H., Kinzler, F., Gaessler, H., Schittko, H., German (FRG) Patent no. 2,423,951, Dec. 1976, In German

For the production of water gas from coal, the inventor proposes to use a stationary cylindrical retort working under increased pressure, with heat input by means of heating pipes. For this heating, the heat energy of a gas should be used which is won in a nuclear reactor. The internal room of the gasification reactor is composed of a perforated low tube in which the steam is fed. This steam forms a fluidized bed of the fed fine-grained coal in the larger upper room. The heating pipes plunge in this fluidized bed. Out of this room, the residues and the produced water gas should be discharged. For the regulation of the coal throughput, the retort or the tub must have an adjustable inclination in the direction of the outlet side. Further claims concern the design of the cooling and the arrangement of the heating pipes.

HP78 22050 PERFORMANCE CHARACTERISTICS OF POTASSIUM HEAT PIPE LOADED WITH ARGON

Fukuzawa, Y., Fujite, Y., (Dept. Nuclear Engng., Osaka Univ., Suita. Japan), J. Nuclear Sci. Tech., V 15:109-119, 1978
No abstract available

HP78 22051 SOLAR ENERGY USES, SYSTEMS, EXPERIENCES, SYMPOSIUM AND ROUNDTABLE CONFERENCE

Gehrke, H., Solar Energy Uses, Systems, Experiences Symposium and Roundtable Conf., Proc., In German

The operation of steam heat-pipe collectors (surface - 65 m^2 storage capacity - 7 m^3) with a plexiglass double-plate cover for space heating and service hot water heating in a single-family home (190 m^2 living area to be heated) in Essen, W. Germany, is described. A simplified layout of the system is presented. During one year, the energy gain was 285 kWH m^2-collector or a total of 18,500 kWH (24 percent of vertical solar radiation). Backup heat is provided by an electric heating system. Based on the data and experience, a collector was developed and is being offered on the market for solar heating and hot water heating. An annual energy gain of 230 to 250 kWH/m^2 in Central Europe is anticipated for the system.

HP78 22052 SPECIFYING SYSTEM COMMISSIONING FOR HEATING, PIPING, AND AIR CONDITIONING SYSTEMS

Gupton, G.W., (Gupton Engng. Assoc., Inc., Atlanta, GA), Heating, Piping, Air Conditioning, V 49:87-92, N11, Nov. 1977
No abstract available

HP78 22053 SAFETY CONSIDERATIONS IN A NUCLEAR ELECTRIC PROPULSION SPACECRAFT

Hsieh, T., Koenig, D., (JPL, Pasadena, CA), J. Spacecraft and Rockets, V 14:756-761, N12, 19 refs, Dec. 1977

Some nuclear safety aspects of a 3.2-MW_t heat-pipe-cooled fast reactor with out-of-core thermionic converters are discussed. Safety-related characteristics of the design, including a thin layer of B 4C surrounding the core, the use of heat pipes and BeO reflector assembly, the elimination of fuel element bowing, etc. are highlighted. Potential supercriticality hazards and countermeasures are considered. Impacts of some safety guidelines of the space transportation system are also discussed briefly. Twelve refs. should result in a thruster that has a highly uniform beam profile, good performance, and a low double-ion population. Experimental results indicate that at about the same thrust and performance levels, the beam flatness parameter of the modified thruster is 40 percent higher and the ratio of the double-to-single ion beam currents is about 40 percent lower than the values measured in the SERT II thruster.

HP78 22054 SOLAR COLLECTORS: TECHNIQUE AND MODE OF OPERATION

Kalischer, F., 1977, In German

Design characteristics and efficiency of different flat-plate collectors (classical type, heat-pipe collector with vacuum insulation) used in photothermal transformation of solar energy into low-temperature heat are discussed. Structural measures to improve efficiency of solar collectors and operational requirements are outlined. Typical uses of flat-plate collectors are demonstrated by four examples: heating of public open-air swimming pools, service hot water heating, space heating, and air conditioning.

HP78 22055 REACTOR AND ADVANCED HEAT TRANSFER TECHNOLOGY

Kirk, W., Energy Tech. Progress Report, Jan.-March 1977

A description of the progress in programs in heat pipe design, development, and fabrication for a variety of applications is presented. LASL efforts supporting the investigation of high-temperature reactors for process heat applications, and a study effort for a space electric power supply (SEPS) are described.

HP78 22056 A LARGE-SCALE HEAT EXCHANGER WITH POLYGONALLY CONFIGURATED HEAT PIPE UNITS

Koizumi, T., Furuya, S., Matsumoto, K., Karawawa, K., (Furukawa Electric Co., Ltd., Tokyo, Japan), 3rd Int. Heat Pipe Conf. Tech. Papers, Palo Alto, CA, p. 76-79, May 22-24, 1978, AIAA, Inc., New York, NY, A78-35538
Avail:AIAA

A large-scale heat exchanger with polygonally configurated heat pipe units is proposed for heat recovery system with large gas flow rate. The length of a heat pipe is restricted by the maximum heat transfer limit and the limit of fabrication, and therefore, the height/width ratio of the face area becomes unbalanced if the heat pipes are arranged in traditional rectangular prism configuration. This makes the installation space unfavorably large and unsymmetrical, and then ducting work also becomes much more difficult. The problem can be resolved by introducing a novel arrangement of heat pipe elements in polygonal configuration. This paper describes outline of the large heat exchanger, some design examples and experimental results of a model heat exchanger with hexagonally configurated heat pipe units.

HP78 22057 HEAT RECOVERING TECHNIQUE BY USING HEAT PIPES

Koizumi, T., Matsumoto, K., (Furukawa Electr. Co., Tokyo, Japan), Keiso, V 20:45-50, 1977

No abstract available

HP78 22058 PROPOSAL TO UTILIZE FUSION REACTOR ENERGY SOURCES FOR CHEMICAL PROCESS APPLICATIONS

Krikorian, O.H., (Univ. of California, Livermore, CA, Lawrence Livermore Lab.), Sept. 22, 1977

We propose to study the utilization of high-temperature (approximately 2000-2500 K) process heat from fusion reactors for large-scale chemical process applications. Of particular interest is the decomposition reaction, CO_2 yields CO + $1/2O_2$, which at 2500 K, should yield approximately 60 percent conversion to CO if O_2 is partially removed through an oxide membrane. Hydrogen can be derived from CO at lower temperatures by reacting CO with steam, and C can also be derived from CO by a disproportionation into C and CO_2 at approximately 1000 K. These chemicals, CO, H_2, and C, form the basis for a multitude of non-electrical energy applications in the areas of transportation, industrial processes, and residential and commercial uses. In addition to the CO_2 decomposition process, we propose to explore a variety of ideas and evaluate them for scientific and economic merit. A follow-on research and development program will be proposed if the ideas prove promising.

HP78 22059 THE CHARACTERISTICS OF HEAT EXCHANGERS USING HEAT PIPES OR THERMOSYPHONS

Lee, Y.; Bedrossian, A., (Dept. of Mech. Engng., Univ. of Ottawa, Ottawa, Canada), Int. J. of Heat and Mass Transfer (GB), V 21:221-229, N2, 1978

The characteristics of counter-flow heat exchanger units, using heat pipes or two-phase closed thermosyphons as the heat-transfer element, are studied experimentally and a simple analytical model was developed to predict the performance of such units using thermosyphons. The maximum heat-transfer rate has a unique functional relationship between the ratio of two stream mass flow rates and the ratio of heated to cooled lengths of the heat transfer elements, regardless of element bundle geometries.

HP78 22060 COST-EFFECTIVENESS STUDY OF HEAT PIPE HEAT EXCHANGERS

Lu, D.C., Feldman, K.T. Jr, (Univ. of New Mexico, Albuquerque, NM), ASME Winter Annual Mtg. Proc., Atlanta, GA, 7 p., Nov. 27-Dec. 2, 1977, A78-33171, Members, $1.50, Non-members, $3.00

The initial costs of three types of heat pipe heat exchangers are presented aluminum-freon 11 for the temperature range from -23 C to 121 C, copper-water for 38 C to 232 C, and carbon steel-dowtherm A for 120 C to 400 C. An optimization computer program for the cost-effectiveness analysis is developed, which takes into consideration the costs for equipment, installation, operation, and maintenance. An optimization example is given for a carbon steel-dowtherm A heat pipe heat exchanger designed to recover heat from the 8534 m^3/min of 316 C flue gas exhausting from the university heating plant boilers.

HP78 22061 SOLAR ENERGY COLLECTOR

Meckler, G., US Patent no. 4,027,653, June 7, 1977
Avail:Patent Office

An infrared solar energy collector is disclosed. The collector comprises a heat absorber which, in a first embodiment, is a tube through which a heat transfer fluid is circulated. The heat absorber is disposed within a larger glass tube. In a modified embodiment, the heat absorber is in the form of a heat pipe which conducts heat to a heat transfer fluid circulated through a manifold. A wick carrying a volatile fluid may also surround the heat pipe. Absorbed heat evaporates the fluid which is in turn condensed on the cooler manifold. Either the entire interior of the glass tube surrounding the heat absorber is under reduced pressure, or an annular region between the surrounding glass tube and a second larger diameter surrounding glass tube is under reduced pressure. An energy director, such as a reflector within the enclosing glass tube, directs solar energy on the heat absorber. The relative positions between the energy director and the heat absorber are changed progressively during the course of each day to enable the maximum utilization of solar energy.

HP78 22062 OPTIMIZE OUT-OF-CORE THERMIONIC ENERGY CONVERSION FOR NUCLEAR ELECTRIC PROPULSION

Morris, J.F., (NASA, Lewis, Cleveland, OH), Conf. for Presentation at Int. Conf. on Plasma Sci, Monterey, CA, 15 p., May 15-17, 1978, Spons. by IEEE, N78-17856/3SL

Current designs for out-of-core thermionic energy conversion (TEC) to power nuclear electric propulsion (NEP) were evaluated. Approaches to improve out-of-core TEC are emphasized and probabilities for success are indicated. TEC gains are available with higher emitter temperatures and greater power densities. Good potentialities for accomodating external high temperature, high power density TEC with heat pipe cooled reactors exist.

HP78 22063 HEAT PIPES FOR SUN ENERGY CONVERSION

Murgu, Z., Murgu, D., Cojocaru, L., Huzum, M., (Centrul de Carcetari Tehnice si Fizice, Iasi, Rumania), Tvardochlieb, E., (Centrul de Carcetari Tehnice si Fizice, Polyester Fibers Plant, Iasi, Rumania), 3rd Int. Heat Pipe Conf. Tech. Papers, p. 408-413, May 22-24, 1978, AIAA, New York, NY, A78-35632

Heat pipes fabricated from copper and employing organic fluids or water as the working fluid have been developed for use with solar collectors. The gravity pipes were tested for operation at angles of inclination from 0 to 90 degrees. A porous structure (glass wool) was adopted to assure efficient circulation of the fluid. Data for heat pipes tested with acetone, ethyl alcohol, freon, or water are reported.

HP78 22064 HEAT PIPE CAPABILITIES AND APPLICATIONS

Ranken, W.A., (LASL, Los Alamos, NM), Rept. on Symp. and Workshop on 5-MWT Solar Thermal Test Facility, 1976

No abstract available

HP78 22065 HIGH TEMPERATURE HEAT PIPES FOR TERRESTRIAL APPLICATIONS

Ranken, W.A., Lundberg, L.B., (Univ. of California, Los Alamos, NM), 3rd Int. Heat Pipe Conf. Tech. Papers, Palo Alto, CA, p. 283-291, May 22-24, 1978, AIAA, Inc., New York, NY A78-35615
Avail:AIAA

A high-temperature heat pipe design is described in which ceramic tubing is used to provide the basic structure and containment. The interior wall of this tubing is lined with a chemically vapor deposited metallic layer to protect the ceramic from the the alkali metal working fluid and furnish a distributive wicking surface. High temperature brazes and ceramic bonding agents are used to seal the assembly. The results of a program to develop such a unit for application to high temperature recuperators are discussed and potential applications to coal conversion and coal utilization systems are reviewed.

HP78 22066 HEAT PIPE HEAT EXCHANGERS FOR SOLAR HOMES

Roberts, C.C.Jr., (Packer Engng. Assoc., Naperville, IL), ASME Pap. no. 77-WA/SOL-7 for Mtg., 12 p., 10 refs, Nov. 27-Dec. 2, 1977

Well-sealed energy conserving homes require a certain ventilation rate to replenish oxygen and remove moisture and odors. The exhausting of internal air to the outside environment results in a loss of energy. Heat pipe heat recovery can recapture a portion of this lost heat. Various types of heat pipe wick designs are presented. Experiments were performed on two small heat pipe heat exchangers recovering heat from exhaust air flows of 24 l/min. Heat recovery effectiveness ranged from 0.27 to 0.6, depending on heat exchanger design. Employing an optimally designed heat pipe heat recovery unit may result in significant energy savings in a well-sealed home.

HP78 22067 A NON-TRACKING MODERATELY FOCUSING HEAT PIPE SOLAR COLLECTOR

Roberts, C.C.Jr., (Packer Engng. Assoc., Naperville, IL), 3rd Int. Heat Pipe Conf. Tech. Papers, p. 114-122, May 22-24, 1978, AIAA, New York, NY, A78-35592

A design for a moderately focusing heat pipe solar collector is presented that incorporates advantages of both flat-plate and concentrating collectors. This collector is utilized primarily for heating, has a heat pipe absorber, and uses the thermal diode effect of the heat pipe to prevent nocturnal heat loss. A prototype collector was constructed and tested using four gravity-assisted heat pipes. The concentration ratio was 3.31 to 1. Test data demonstrated collector efficiencies near 60 percent at low loss factor. Absorber temperatures ranged from 40 to 55 C.

HP78 22068 ENERGY SAVINGS POTENTIAL OF HVAC AIR-TO-AIR HEAT RECOVERY EXCHANGERS

Sauer, H.J.Jr., Howell, R.M., (Univ. of Missouri, Rolla, MO), Heat Transfer in Energy Conserv., Proc. p. 65-74, Nov. 27-Dec. 2, 1977, Winter Annual Mtg. of ASME, Atlanta, GA, Publ. by ASME, New York, NY

This paper describes and discusses the principles, advantages, and disadvantages of several types of air-to-air energy recovery systems, the heat pipe exchanger, the thermal wheel, and the plate exchanger. Emphasis is placed on the potential energy savings in heating and cooling equipment and fuel costs by recovering energy from exhaust air before it is thrown away. Results indicate annual energy savings up to 23 percent with even larger savings in the size of the heating and cooling equipment. As expected, greatest savings occur when large amounts of outside air are required for ventilation.

HP78 22069 COOLING WITH SOLAR ENERGY

Schubert, K., Dreyer, J., 1977, In German

This is a report on development work on solar refrigeration. As the refrigeration requirements and solar energy available are equalized, there is no necessity for long-term storage. The system is independent of any external energy supply, and shows a simple construction requiring little maintenance compared with compressor-type refrigerators. High efficiency enables one to use compact plants for room air conditioning. Such plants are of great importance for developing countries, where considerable quantities of food now rot because of lack of refrigeration.

HP78 22070 ENERGY CONSERVATION IN GRAIN DRYERS USING HEAT PIPE EXCHANGERS

Sokhansanj, S., (Michigan State Univ., East Lansing, MI), 191 p., 1977, PhD

No abstract available

HP78 22071 APPLICATION OF HEAT PIPE EXCHANGERS IN COMMERCIAL GRAIN DRYERS

Sokhansanj, S., Bakker-Arkema, F.W., (Michigan State Univ., East Lansing, MI), Paper ASAE for Annual Mtg., NC State Univ., Raleigh, NC, 14 p., June 26-29, 1977, Pap. no. 77-3019, Publ. by ASAE, St. Joseph, MI

A heat pipe exchanger was used experimentally in a concurrent-counterflow grain dryer and savings from 15 to 18 percent were obtained. The economic analysis of heat pipe exchangers and the commercial grain dryers showed that application of the device will result in substantial net annual savings. Grain dust accumulation (fouling) of the heat pipe exchanger is also analyzed.

HP78 22072 NUMERICAL SIMULATION OF PASSIVE SOLAR HEATING SYSTEMS

Stickford, G.H., Jacob, F.E., Corliss, J.M., (Battelle Columbus Labs., Columbus, OH), Conf. on Systems Simulation and Economic Analysis for Solar Heating and Cooling, San Diego, CA, June 27-29, 1978

Avail:TAC

A numerical simulation utilizing a finite difference technique was developed to predict the performance of passive solar systems. Theoretical results are compared with measured data in order to verify the computer model. The model was used to evaluate the performance of several different passive solar heated water wall configurations. Results show that a heat pipe embedded water wall provides an additional improvement over the other configurations which were considered.

HP78 22073 HIGH-TEMPERATURE THERMAL ENERGY STORAGE, INCLUDING A DISCUSSION OF TES INTEGRATED INTO POWER PLANTS: BOOK

Turner, R.H., (California Inst. of Tech., JPL, Pasadena, CA), 101 p., 1978, Franklin Inst. Press, Philadelphia, PA, A78-34468, $6.50

Storage temperatures of 260 C and above are considered. Basic considerations concerning energy thermal storage are discussed, taking into account general aspects of thermal energy storage, thermal energy storage integrated into power plants, thermal storage techniques and technical considerations, and economic considerations. A description of system concepts is provided, giving attention to a survey of proposed concepts, storage in unpressurized fluids, water storage in pressurized containers, the use of an underground lined cavern for water storage, a submerged thin insulated steel shell under the ocean containing pressurized water, gas passage through solid blocks, a rock bed with liquid heat transport fluid, hollow steel ingots, heat storage in concrete or sand, sand in a fluidized bed, sand poured over pipes, a thermal energy storage heat exchanger, pipes or spheres filled with phase change materials (PCM), macroencapsulated PCM with heat pipe concept for transport fluid, solid PCM removed from heat transfer pipes by moving scrapers, and the direct contact between PCM and transport fluid.

II. D. AEROSPACE APPLICATIONS

HP78 23019 STUDY AND DESIGN OF A MODULAR PHASE CHANGE MATERIAL THERMAL CAPACITOR FOR APPLICATION TO SPACELAB PAYLOADS

Abhat, A., Hage, M., Dietrich, G., (Stuttgart Universitaet, Stuttgart, W. Germany), 2nd Thermophysics and Heat Transfer Conf., Palo Alto, CA, 10 p., May 24-26, 1978, AIAA and ASME, European Space Res. and Tech. Centre, A78-36010

The thermal and structural design analysis of a modular phase change material (PCM) thermal capacitor for application to the thermal conditioning of spacelab payloads is described. The modular system comprises of up to six modules, each of 500 wh storage capacity, stacked together. A combination of heat pipes and honeycomb is used as the filler, octadecane as the PCM. With 15 heat pipes, the overall temperature gradient is computed to be 20 K for a heat input rate of 500 W and heat storage in all six modules. The structural analysis shows the provision of 12 3/16-in steel bolts equally distributed along the periphery to suffice to hold the modules together in launch and orbital vibration environments.

HP78 23020 ESA HEAT PIPE PROGRAMME

Accensi, A., Savage, C.J., (ESA, European Space Res. and Tech. Centre, Noordwijk, Netherlands), 3rd Int. Heat Pipe Conf., Palo Alto, CA, p. 377-382, May 22-24, 1978, AIAA, New York, NY, A78-35627
Avail:AIAA

The ESA heat pipe research program focuses on applications of heat pipes to the thermal control of communications payloads of communications satellites, to the cooling of detectors on scientific satellites, and to the thermal conditioning of spacelab payloads. Development plans for constant conductance and variable conductance heat pipes operating in the range from -10 to +70 C, as well as for cryogenic heat pipes and diodes, are presented. Mechanical qualification, life testing, and zero-G testing of the heat pipe systems are considered.

HP78 23021 OPTIMIZING A LOW-COST SATELLITE ENERGY SYSTEM

Drummond, J.E., (Maxwell Labs., Inc., San Diego, CA), Proc. of 12th Intersoc. Energy Conversion Engng. Conf., V 2, 1977, Am. Nuclear Soc., Inc., La Grange Park, IL

The potential advantages of proposed geostationary power satellites frustrated by probably ionospheric damage and high cost encouraged the derivation and now the optimization of a modified satellite power system using lower, sun-synchronous orbits designed to minimize the limitations while avoiding creation of comparable new limitations. The previously proposed iso-insolation power satellite (IPS) system would, among other things, eliminate localized enhancement of electron density in the ionosphere arising from and deflecting microwave transmission from power satellites, introduce a new satellite form which appears to be an improvement on current designs, significantly reduce power converter mass through utilization of a ferroelectric heat engine, and greatly reduce the size and weight of both the transmitting and receiving antennas due to the much shorter microwave link. It appears that a relatively simple derivative of the space shuttle could be used to implement the IPS system, and that, once implemented, such a system could provide power continuously worldwide at a cost significantly lower than fossil or nuclear power. A condition on the system's economy is that it must have load centers distributed throughout the world including the oceans where hydrogen could be produced for mobile vehicle use.

HP78 23022 SATELLITE BATTERY TEMPERATURE CONTROL USING VARIABLE CONDUCTANCE HEAT PIPES

Edelstein, F., (Grumman Aerospace Corp., Bethpage, NY), Flieger, H., (Communications Satellite Corp., Clarksburg, MD), 3rd Int. Heat Pipe Conf., Palo Alto, CA, p. 360-366, May 22-24, 1978, AIAA, Inc., New York, NY, A78-35624
Avail:AIAA

A non-flight prototype 25-cell nickel-cadmium battery thermal control system using active feedback control variable conductance heat pipes has been designed, built, and tested. The thermal design of the battery limits cell temperatures to the range of 10 C to 15 C over all thermally extreme orbital environments. This relatively narrow temperature band, along with a maximum one C cell-to-cell gradient, is expected to extend battery life in future satellites to a 10-year period. The heat pipe-battery system has successfully completed three-axis sinusoidal vibration testing and its performance has been verified during extensive thermal vacuum tests.

HP78 23023 TRANSVERSE FLAT-PLATE HEAT PIPE EXPERIMENT

Edelstein, F., (Grumman Aerospace Corp., Bethpage, NY), 3rd Int. Heat Pipe Conf., Palo Alto, CA, p. 254-259, May 22-24, 1978, Tech Papers., AIAA, Inc., New York, NY, A78-35611
Avail:AIAA

This paper describes a shuttle-launched flight experiment to evaluate the performance of a transverse flat-plate heat pipe that serves as an integral temperature control-mounting panel for electronic equipment. A transverse heat pipe is a gas-controlled variable conductance heat pipe that can handle relatively large thermal loads. An experiment designed to flight test the concept over a six to nine-month period is self-sufficient with respect to electrical power, timing sequences, and data storage.

HP78 23024 A HIGH RELIABILITY VARIABLE CONDUCTANCE HEAT PIPE SPACE RADIATOR IN SATELLITE DESIGN

Fleischman, G.L., (Hughes Aircraft Co., Torrance, CA), Pasley, G.F., McGrath, R.J., Loudenback, L.D., (Hughes Aircraft Co., Space and Communications Group, El Segundo, CA), 3rd Int. Heat Pipe Conf., Palo Alto, CA, p. 216-226, May 22-24, 1978, AIAA, Inc., New York, NY, A78-35606
Avail:AIAA

The heat pipes in this radiator for space applications incorporate a central-core wrapped screen wick, which primes and reprimes under adverse conditions in the presence of non-condensable gas. A step change in mesh size provides low resistance to liquid flow in the condenser while at the same time retaining high pumping capability in the evaporator region. The envelope and wick material is stainless steel for a turndown ratio of 6000 to 1. The design offers high thermal transport at relatively high tilt angles, thus reducing spacecraft leveling requirements. The working fluid is ammonia. Spacecraft thermal design considerations are presented, as well as thermal vacuum testing of the space radiator.

HP78 23025 EVALUATION OF COMMERCIALLY AVAILABLE SPACECRAFT-TYPE HEAT PIPES

Kaufman, W.B., Tower, L.K., (NASA, Lewis, Cleveland, OH), 3rd Int. Heat Pipe Conf. Tech. Papers, Palo Alto, CA, p. 88-95, May 22-24, 1978, AIAA, Inc., New York, NY, A78-35590
Avail:AIAA

As part of an effort to develop reliable, cost-effective spacecraft thermal control heat pipes, Lewis Research Center of NASA is conducting life tests on 30 commercially available heat pipes in 10 groups of different design and material combinations. Materials are aluminum and stainless steel, and working fluids are methanol and ammonia. The formation of non-condensable gas is observed for times exceeding 11,000 hours. The heat transport capacities of the pipes are also determined. Considerable gas is found in two groups of methanol pipes; one group shows no gas. One group of ammonia pipes has no observable gas. Another group has much gas. Manufacturers' processing schedules are examined for differences explaining the presence of gas. Heat transport capacity is found to be severely reduced in some pipes containing gas.

HP78 23026 DEVELOPMENT OF A MODULAR HEAT PIPE RADIATOR SYSTEM FOR SPACE APPLICATIONS

Koch, H., Hinderer, B., (Dornier System GMBH, Friedrichshafen, W. Germany), Pawlowski, P., (Deutsche Forschungs und Versuchsanstalt Fuer Luft und Raumfahrt, Cologne, W. Germany), 3rd Int. Heat Pipe Conf., Palo Alto, CA, P. 245-253, May 22-24, 1978, Tech. Papers, AIAA, New York, NY, A78-35610
Avail:AIAA

Design and operating characteristics of a modular radiator system are described with reference to applications to the cooling of scientific instruments in space. A space simulation chamber was used to test layout schemes and basic hardware function. Factors tested include the influence of heat input variation, fluctuations in solar radiation, and vibration. Each modular component is designed to transport a dissipation heat of 80 w at a 40 C to the radiator surface. Attention is given to optimized dimensions for heat pipes and to the insulation characteristics of the reservoirs for all three modular types, e.g., fixed conductance, active gas controlled, and passive gas controlled.

HP78 23027 HEAT PIPE NUCLEAR REACTORS FOR SPACE APPLICATIONS

Koenig, D.R., Ranken, W.A., (Univ. of California, Los Alamos, NM), 3rd Int. Heat Pipe Conf. Tech. Papers, Palo Alto, CA, p. 391-397, May 22-24, 1978, AIAA, Inc., New York, NY, A78-35629
Avail:AIAA

A heat pipe nuclear reactor design concept is being investigated for space power applications. The reactor can be coupled to a variety of high-temperature (1200-1700 K) electrical conversion systems such as thermoelectric, thermionic, and Brayton cycle converters. It is designed to operate in the power range 0.1 to 3 MW_t for lifetimes of about 10 years. The reactor is a fast spectrum, compact assembly of hexagonal fuel elements, each cooled by an axial molybdenum heat pipe and loaded with fully enriched UC-ZrC or $MO-UO_2$. Reactor control is provided in the radial reflector. A comparison of several power plants employing the heat pipe reactor concept is presented for an output power level of 50 KWe.

HP78 23028 A MASS- OPTIMIZED HEAT PIPE RADIATOR FOR THE COMMUNICATION SPACECRAFT "ARCOMSAT"

Kreeb, H., (Dornier System GMBH, Friedrichshafen, W. Germany), 3rd Int. Heat Pipe Conf. Tech. Papers, Palo Alto, CA, p. 241-244, May 22-24, 1978, AIAA, Inc., New York, NY, A78-35609
Avail:AIAA

For the planned communication spacecraft Arcomsat, a heat pipe radiator had been designed, manufactured, and tested successfully. The north-south panel of the Arcomsat is provided with electronic components such as TWTS, EPCS, and amplifiers. Heat due to energy losses are dissipated directly into these panels which radiate the energy to space. The main dissipation energy is produced by two amplifiers, located in a relatively small area. The dissipation heat of these two amplifiers should be distributed nearly isothermal over the whole radiator surface with about $1.7/m^2$ (1.3 m x 1.5 m). The weight of the complete radiator is limited to about 4.3 kg. Heat pipes integrated in the honeycomb core of the radiator panel are selected for this energy distribution.

HP78 23029 DESIGN OF A GAS-CONTROLLED HEAT PIPE RADIATOR FOR A MAROTS-TYPE TPA-RADIATOR APPLICATION

Kreeb, H., Perdu, M., (Dornier System GMBH, Friedrichshafen, W. Germany), Savage, C., (ESA, European Space Res. and Tech. Centre, Noordwijk, Netherlands), 3rd Int. Heat Pipe Conf., Tech. Papers, Palo Alto, CA, p. 233-240, May 22-24, 1978, AIAA, Inc., New York, NY, A78-35608
Avail:AIAA

In an effort to control the thermal environment of a Marots spacecraft payload, a gas-controlled heat pipe radiator was designed with the following components: a mounting plate with five thermalizer heat pipes, two bent radiator panels with four gas-controlled heat pipes each, and thermal insulation blankets for the mounting plate and reservoirs. Design and operating parameters of the system are discussed with attention to specific goals and constraints, including beginning of life with a maximum power dissipation of 130 w at equinox, and minimum thermal interference to S/C ratio. Calculations are presented for system operation under worst case conditions. Results indicate that cooling requirements can be met within acceptable mass constraints.

HP78 23030 DESIGN AND EVALUATION OF A ROTATING VARIABLE CONDUCTANCE HEAT PIPE SYSTEM IN DYNAMICS EXPLORER HIGH ORBITER SPACECRAFT

Marshburn, J.P., McIntosh, R.Jr., (NASA, Goddard, Greenbelt, MD), 3rd Int. Heat Pipe Conf. Tech. Papers, Palo Alto, CA, p. 211-215, May 22-24, 1978, AIAA, New York, NY, A78-35605
Avail:AIAA

Analysis of the dynamics explorer high orbiter spacecraft showed that the proposed louver system, along with existing radiator heat rejection areas on the S/C surface were insufficient to safely control the S/C's thermal excursions caused by highly varying internal power levels and solar input angles. A variable conductance heat pipe system in conjunction with a conventional radial heat pipe system was designed, built, tested, and shown to resolve this problem. The conventional pipes, radial, spinning at 10 rpm were required to carry 35 watts each after experiencing despin from 30 rpm. The VCHPS attached to the radial pipes at the S/C perimeter distributed the excess energy via a finned radiator attached around the S/C's center.

HP78 23031 A THERMAL CANISTER EXPERIMENT FOR THE SPACE SHUTTLE

McIntosh, R., Ollendorf, S., (NASA, Goddard, Greenbelt, MD), 3rd Int. Heat Pipe Conf. Tech. Papers, Palo Alto, CA, p. 402-407, May 22-24, 1978, AIAA, Inc., New York, NY, A78-35631
Avail:AIAA

An experiment will be described which, if successful, will demonstrate the feasibility of using a heat pipe thermal canister to control the temperature of a wide variety of instruments operating in the bay of the NASA space shuttle. The experiment will be launched in December 1979 as part of the fourth orbital flight test of the shuttle. Predictions indicate that the canister can provide an environment controlled to ± one C over the range of 0 C to 30 C for conductively and radiatively coupled instruments with internal power dissipations of approximately 100 to 400 watts. This is the most ambitious thermal control program yet attempted which uses heat pipes as the primary control element. The outcome of this experiment will have far reaching implications for instruments which are operated in the shuttle bay.

HP78 23032 HIGH-TEMPERATURE HIGH-POWER-DENSITY THERMIONIC ENERGY CONVERSION FOR SPACE

Morris, J., (NASA, Lewis, Cleveland, OH), 17 p., 1977, N78-13890/6SL

Theoretic converter outputs and efficiencies indicate the need to consider thermionic energy conversion (TEC) with greater power densities and higher temperatures within reasonable limits for space missions. Converter output power density, voltage, and efficiency as functions of current density were determined for 1400 to 2000-K emitters with 725 to 1000-K collectors. The results en ourage utilization of TEC with hotter-than-1650 K emitters and greater-then-6W cm^2 output to attain better efficiencies, greater voltages, and higher waste-heat-rejection temp ratures for multihundred-kilowatt space-power applications. For example, 1800 K, 30 a cm^2 TEC operation for NEP compared with the 1650 K, 5 a cm^2 case should allow much lower radiation weights, substantially fewer and/or smaller emitter heat pipes, significantly reduced reactor and shield-related weights, many fewer converters and associated current-collecting bus bars, less power conditioning, and lower transmission losses. Integration of these effects should yield considerably reduced NEP specific weights.

HP78 23033 HEAT PIPES IN SPACE, AND ON EARTH

Ollendorf, S., (NASA, Goddard, Greenbelt MD), 14th Annual Mtg. and Tech. Display of AIAA, 5 p., Feb. 7-9, 1978, Washington, D.C., 78-24005
Avail:AIAA

The heat pipe is a closed tube whos inner surfaces are lined with a porous capillary wick. The wick is saturated with the li uid phase of a working fluid. The heat supplied at one end of the tube, the evaporator, auses evaporation of the working fluid. The vapor will pass to the other end of the tube, the condenser, where it will condense and release the latent heat of vaporization to a heat sink in that section of the pipe. Problems concerning a design of heat pipes for space applications are related to certain difficulties regarding the prediction of device performance under zero-G conditions. Heat pipes are usually tested on the ground under the influence of gravity, and then their performance is extrapolated to space. A description is presented of the approaches used to insure good heat pipe performance in space. Attention is given to an international heat pipe experiment conducted to accumulate zero-G performance data for several new and unique heat pipe designs, heat pipes for ATS-6, cryogenic heat pipes, and future activities.

HP78 23034 THERMAL CONTROL CANISTER

Ollendorf, S., (NASA, Goddard, Greenbelt, MD), 28 p., 1977, N78-13380/8SL

A heat dissipating instrument package of a spacecraft, located in a canister having walls in heat transfer relationship with the package, is maintained at a substantially constant temperature. Fixed conductance heat pipes on the canister walls are connected to variable conductance heat pipes, mounted on a radiator structure separated from the canister walls by a thermal blanket. The effective radiating area of the radiator structure is controlled by the variable conductance heat pipes in response to a comparison of a sensed temperature of the instrument package or the canister wall with a set point value. The comparison controls a heater in a gas reservoir containing a non-condensable gas of the variable conductance heat pipe. A thermal radiation shield for the gas reservoir prevents radiant energy from the exterior environment and thermal energy reflected from the spacecraft from overheating the non-condensable gas.

HP78 23035 PROCEDURE OF A SPACE QUALIFICATION FOR AN AXIAL GROOVED HEAT PIPE

Perdu, M., Kreeb, H., (Dornier System GMBH, Friedrichshafen, W. Germany), Pawlowski, P., (Deutsche Forschungs und Versuchsanstalt Fuer Luft und Raumfahrt, Cologne, W. Germany), 3rd Int. Heat Pipe Conf. Tech. Papers, Palo Alto, CA, p. 383-390, May 22-24, 1978, AIAA, Inc., New York, NY, A78-35629
Avail:AIAA

Space qualification of axially grooved heat pipes fabricated from aluminum and employing ammonia as the working fluid is discussed. The qualification procedure involves vibration, shock, and pressure testing, as well as exposure to thermal cycling and thermal shocks. Start-up behavior of the heat pipes after acceleration or with frozen working fluid is also assessed. The sealing process and chemical cleaning of the pipes appear to be the manufacturing steps presenting the most difficulties in assuring the quality of the heat pipes.

HP78 23036 DESIGN CONSIDERATIONS FOR A NUCLEAR ELECTRIC PROPULSION SYSTEM

Phillips, W.M., Pawlik, E.V., (California Inst. of Tech., JPL, Pasadena, CA), 13th Int. Electric Propulsion Conf. Proc., San Diego, CA, 11 p., April 25-27, 1978, AIAA, Deutsche Gesellschaft Fuer Luft und Raumfahrt, ERDA-spons. Res., A78-32763
Avail:AIAA

A study is currently underway to design a nuclear electric propulsion vehicle capable of performing detailed exploration of the outer planets. Primary emphasis is on the power subsystem. Secondary emphasis includes integration into a spacecraft, and integration with the thrust subsystem and science package or payload. The results of several design iterations indicate an all-heat pipe system offers greater reliability, elimination of many technology development areas and a specific weight of under 20 kg/KWe at the 400 KWe power level. The system is compatible with a single shuttle launch and provides greater safety than could be obtained with designs using pumped liquid metal cooling. Two configurations, one with the reactor and power conversion forward on the spacecraft with the ion engines aft and the other with reactor, power conversion, and ion engines aft were selected as dual baseline designs based on minimum weight, minimum required technology development, and maximum growth potential and flexibility.

HP78 23037 HEAT PIPES FOR UPPER STAGE AVIONICS THERMAL CO TROL

Pleasant, R.L., (General Dynamics Corp., Convair Div., San Diego, CA), 3rd Int. Heat Pipe Conf. Tech. Papers, Palo Alto, CA, p. 398-401, May 22-24, 1978, AIAA, Inc., New York, NY A78-35630
Avail:AIAA

A test article representing an upper stage avionics thermal control system was developed and tested under simulated space environments of full-sun and no-sun. The upper stage avionics packages are located in space-viewing windows. Heat is carried from package mounting plates to cylindrical secondary rad ator skins by heat pipes. Test results were correlated and simulated with an analyt cal model of the test article. The selected window module approach was found to be vers tile, to allow repeated package removal with no performance penalty, and to operate atisfactorily with a simulated one-heat-pipe-out failure.

HP78 23038 DEVELOPMENT OF A TECHNOLOGICAL MODEL VARIABLE CONDUCTANCE HEAT PIPE RADIATOR FOR MAROTS-TYPE COMMUNICATION SPACECRAFT

Savage, C.J., Aalders, B.G.M., (ESA, European Space Res. and Tech. Centre, Noordwijk, Netherlands), Kreeb, H., (Dornier System GMBH, Friedrichshafen, W. Germany), 3rd Int. Heat Pipe Conf. Tech. Papers, Palo Alto, CA, p. 227-232, May 22-24, 1978, AIAA, Inc., New York, NY, A78-35607
Avail:AIAA

A technology model variable conductance heat pipe (VCHP) radiator has been designed, built, and tested, and has been life testing now for about 14 months at Estec. The design constraints were based on the anticipated thermal control requirements for the microwave transistor power amplifiers intended for the Marots satellite. Thus the radiator was required to maintain all operating amplifiers within five C of one another and within the temperature range of 30 to 40 C. The radiator must also provide protection during extended powered-down periods and during eclipse. Experimental results are presented showing performance at the beginning of life and after the first 12 months of life testing.

HP78 23039 A MECHANICAL, THERMAL, AND ELECTRICAL PACKAGING DESIGN FOR A PROTOTYPE POWER MANAGEMENT AND CONTROL SYSTEM FOR THE 30-CM MERCURY ION THRUSTER

Sharp, G.R., Gedeon, L., Oglebay, J.C., Shaker, F.S., Siegert, C.E., (NASA, Lewis, Cleveland, OH), 13th Int. Electric Propulsion Conf. Proc., San Diego, CA, 31 p., April 25-27, 1978, AIAA, Deutsche Gesellschaft Fuer Luft und Raumfahrt, A78-32759
Avail:AIAA

A prototype electric power management and thruster control system for a 30-cm ion thruster has been built and is ready to support a first mission application. The system meets all of the requirements necessary to operate a thruster in a fully automatic mode. Power input to the system can vary over a full two to one dynamic range (200 to 400 V) for the solar array or other power source. The power management and control system is designed to protect the thruster, the flight system, and itself from arcs and is fully compatible with standard spacecraft electronics. The system is designed to be easily integrated into flight systems which can operate over a thermal environment ranging from 0.3 to 5 au. The complete power management and control system measures 45.7 cm x 15.2 cm x 114.3 cm and weighs 36.2 kg. At full power the overall efficiency of the system is estimated to be 87.4 percent. Three systems are currently being built and a full schedule of environmental and electrical testing is planned.

HP78 23040 HEPP: A LOW-TEMPERATURE HEAT PIPE EXPERIMENT PACKAGE DEVELOPED FOR FLIGHT ON-BOARD THE LONG DURATION EXPOSURE FACILITY (LDEF)

Suelau, H.J., Brennan, P.J., (B & K Engng., Inc., Towson, MD), McIntosh, R., (NASA, Goddard, Greenbelt, MD), 3rd Int. Heat Pipe Conf. Tech. Papers, Palo Alto, CA, p. 418-425, May 22-24, 1978, AIAA, Inc., New York, NY, A78-35634
Avail:AIAA

The heat pipe experiment package (HEPP) is designed to provide a flight evaluation system for low-temperature heat pipes. The HEPP will be flown aboard the long duration exposure facility which will be launched and retrieved as part of the space shuttle program. The experiment contains two heat pipes, an axially grooved fixed conductance heat pipe, and a liquid blockage thermal diode. A phase change material canister is also integrated with a radiant cooler system. Additional hardware consists of supporting electrical equipment, including electronics for signal conditioning and command functions, a data recorder, and a hermetically sealed battery which powers the experiment. A thermal model was developed to simulate the behavior of the HEPP and a ground test program was conducted to verify the predicted performance of the equipment.

HP78 23041 "T-SYSTEM:" PROPOSAL OF A NEW CONCEPT HEAT TRANSPORT SYSTEM

Tamburini, P., (ESA, European Space Res. and Tech. Centre, Noordwijk, Netherlands), 3rd Int. Heat Pipe Conf. Tech. Papers, Palo Alto, CA, p. 346-353, May 22-24, 1978, AIAA, Inc., New York, NY, A78-35623
Avail:AIAA

A heat transport system which relies on pressure changes generated by evaporation and condensation of the working fluid to drive circulation is described. The heat transport system, which requires no conventional pump, can work against gravity and consequently may be tested on the ground before launch in a spacecraft. In addition, the system offers a high degree of flexibility in design, accommodating bends, elbows, and flex hoses with no major limitations. A bench model of the heat transport system has been tested; applications of the concept to thermal control in spacelab payloads and to solar energy collection are mentioned.

HP78 23042 HIGH TEMPERATURE HEAT PIPE RESEARCH AT NASA LEWIS RESEARCH CENTER

Tower, L.K., Kaufman, W.B., (NASA, Lewis, Cleveland, OH), 3rd Int. Heat Pipe Conf. Tech. Papers, Palo Alto, CA, p. 303-311, May 22-24, 1978, AIAA, Inc., New York, NY, A78-35618
Avail:AIAA

In the course of studies of thermionic power plants for space applications, high-temperature refractory metal heat pipes have been designed and built for alkali metal working fluids. Fabrication of tungsten wire-reinforced tantalum pipes by chemical vapor deposition is discussed; the development of reinforced pipes with integral arteries produced by chemical vapor deposition is also mentioned. The feasibility of using lithium, sodium, potassium, cesium, or mercury as the working fluid in the heat pipes is also reviewed. Operation of a lithium-filled heat pipe of about three-kW capacity for several thousand hours is reported.

HP78 23043 SPACE SOLAR POWER STATIONS

Vanke, V.A., Lopukhin, V.M., Savvin, V., (Moskovskii Gosudarstvennyi Universitet, Moscow, USSR), Uspekhi Fizicheskikh Nauk, V 123:633-655, Dec. 1977, In Russian, A78-27442

The paper surveys the current status of studies on solar power stations in geosynchronous orbit, which would convert solar energy into electric power and transmit it to earth by microwave. Basic schemes for such a system are presented, economic estimates are made, and the prospects for developing orbiting solar power stations are discussed.

HP78 23044 THERMAL CONTROL SUBSYSTEM OPTIMIZATION, A NEW APPROACH

Ward, T.L., (Martin Marietta Aerospace, Denver, CO), 2nd Thermophysics and Heat Transfer Conf.,Proc., Palo Alto, CA, 8 p., May 24-26, 1978, AIAA, ASME, Res. Spons. by Martin Marietta Aerospace, A78-36008
Avail:AIAA

A new approach has been developed for establishing optimized weights for thermal control subsystems. The approach is suited for preliminary design studies where it is necessary to select a preferred thermal control subsystem among a set of candidates. The results of the analytical technique presented in this paper are the optimized weight, radiator area, and heater power requirement for a given subsystem. For a spacecraft program these results are typically included in a subsystem trade where cost and schedules are factored into the final selection process. Six types of thermal control subsystems have been programmed. Program inputs include component temperature limits, the orbital radiation environment, interface conductance values, and radiator surface properties. The unique feature of this approach is that with one pass through the computer, both hot and cold cases are considered and the optimized weight is identified.

II. E. ELECTRICAL AND ELECTRONIC APPLICATIONS

HP78 24005 PROCEEDINGS OF THE TECHNICAL PROGRAM, NATIONAL ELECTRONIC PACKAGING AND PRODUCTION CONFERENCE, 1977

Anon., (Ind. and Sci. Conf. Manage., Chicago, IL), Conf. Proc., Anaheim, CA, 508 p., March 1-3, 1977; Philadelphia, PA, May 17-19, 1977, Publ. by Ind. and Sci. Conf. Manage.

This symposium of 68 papers covers the following topics: improved multilayer performance with new laminate materials; practical applications of photochemical machining; chip carrier systems in ceramic and plastics; use of evaluation of fiber optics in electronic systems; flexible circuits-reliability through design and testing; surface finishes for quality soldering; cost consideration and economic control in circuit manufacturing; a survey of industry-wide circuit testing set-up; artwork generation; current trends in PC board manufacture and soldering; soldering-procedure and materials; reduction of set-up costs for ATE; thermal problems; microwave packaging; and, multiplex wiring impact on packaging connectors. Selected papers are indexed separately.

HP78 24006 HEAT PIPES IN ELECTRONIC COMPONENT PACKAGING

Basiulis, A., Sekhon, K.S., (Hughes Aircraft Co., Torrance, CA), Proc. of Tech. program Nat'l Electron. Packag. Prod. Conf., Anaheim, CA, March 1-3, 1977; Philadelphia, PA, May 17-19, 1977, p. 410-419, 14 refs, Publ. by Ind. and Sci. Conf. Manage., Chicago, IL

Heat pipes in electronic component packaging provide many advantages over conventional cooling methods by reducing component temperatures, eliminating hot spots, and providing design flexibility. Because of these features, heat pipes are slowly gaining acceptance in industry. Applications include heat pipes cooling components inside hermetically sealed enclosures, removing heat from flat packs, serving as an isothermal mounting plate for an amplifier on a spacecraft, or doubling as a structural member and thermal conductor to cool a solid-state module. Developments are even under way to integrate heat pipes into circuit cards and to build heat pipes into power transistors. Heat pipes in actual electronic packaging applications, and those under development are discussed. Performance characteristics of heat pipes will be given, and examples of how thermal problems in electronic packaging were solved through the use of heat pipes are described.

HP78 24007 STIMULATED ELECTRONIC RAMAN SCATTERING IN Cs VAPOR: A SIMPLE TUNABLE LASER SYSTEM FOR THE 2.7 TO 3.5 MICRON REGION

Cotter, D., Hanna, D.C., (Southampton Univ., Southampton, England), Optical and Quantum Electronics, V 9:590-518, Nov. 1977, Res. Supp. by Paul Instrument Fund and Sci. Res. Council, A78-12440

Stimulated electronic Raman scattering (SERS) in atomic vapors provides a simple method of extending the tuning ranges of pulsed dye lasers well into the infrared region. The special advantages of this technique in comparison with other types of tunable infrared lasers are discussed, and are illustrated by describing a SERS system which uses a modest nitrogen laser-pumped dye laser (about 20 kw). This produces infrared radiation tunable from 2.67 to 3.47 microns by SERS in cesium vapor, which is contained in a heat pipe oven. Photon conversion efficiencies of up to 50 percent are obtained. The heat pipe oven design, system operation, and optimization of experimental parameters are described in detail.

HP78 24008 SODIUM VAPOR HEAT PIPE LASER CELL

Deverall, J.E.; York, G.W., (Univ. of California, Los Alamos, NM), 3rd Int. Heat Pipe Conf. Tech. Papers, Palo Alto, CA, p. 71-75, May 22-24, 1978, AIAA, Inc., New York, NY, A78-35587
Avail:AIAA

A sodium heat pipe cell containing high-voltage discharge plates was constructed to study the band absorption of light by the sodium dimer and to determine the feasibility of creating a metal vapor laser. Spectrographic measurements indicated that the increase in sodium dimer population with temperature resulted in 90 percent light absorption at 970 K. High-voltage discharges in the sodium vapor dissociated the dimers and restored transparency to the medium. No lasing action of the sodium vapor with high-voltage discharges was observed either because of insufficient ionization or nonuniformity of the ionization over the plate area.

HP78 24009 DEVELOPMENT OF A TRANSCALENT SILICON POWER SWITCHING TRANSISTOR

Eaton, R.III, Kessler, S.W.Jr., Reed, R.E., (USA Meradcom, Ft. Belvoir, VA), Conf. Recess of IAS 12th Annual Mtg., Los Angeles, CA, p. 1032-1041, Oct. 2-6, 1977, 15 refs, Publ. by IEEE, New York, NY, Cat. no. 77CH1246-8-IA
Avail:IEEE

This paper describes the design, construction, electrical performance, and thermal characteristics of a unique 100 A, 750 V, 500 w dissipation NPN transcalent transistor. The term "transcalent" describes the use of integral heat pipe cooling for improved performance. Parameters discussed in the paper are the gain, voltage ratings, current ratings, turn-on and turn-off times, thermal impedance, as well as the thermal computations for the transistor and its heat pipes. The safe operating area of the transistor is also presented and the characteristics of the device are discussed for the switching of 24 kVA into a resistive load. This transistor has potential applications both to industrial and military equipment in power conditioning, voltage regulation, motor speed control, arc suppression, amplifier and power switching applications.

HP78 24010 ELECTRONIC EQUIPMENT COLD PLATES

Feldmanis, C.J.; (Air Force Flight Dynamics Lab, Wright-Patterson AFB, OH), Final Rept., June 1975-April 1976, 459 p.

Experimental and analytical work have been performed to investigate capabilities and thermal performance characteristics of cold plates for electronic equipment cooling. The effort includes air-cooled cold plates, liquid-cooled cold plates, and cold plates provided with heat pipes. Different designs were selected for each of the three categories and thermal tests at different coolant flow and equipment power dissipation rates performed. It has been shown that large amounts of equipment waste heat can be removed by this cooling technique and thermal performance accurately predicted, particularly with computer-aided analysis.

HP78 24011 APPLICATION OF HEAT PIPES IN ELECTRONIC MODULES

Nelson, L.A., Sekhon, K.S., Ruttner, L.E., (Hughes Aircraft Co., Fullerton, CA), 3rd Heat Pipe Conf Tech. Papers, Palo Alto, CA, p. 367-372, May 22-24, 1978, AIAA, Inc., New York, NY, A78-35625

Avail:AIAA

The design of heat pipes for ciucuit cards is discussed, with special attention given to heat pipes developed for the thermal control systems of the US Navy's Standard Electronics Module (SEM). The heat pipes discussed here are fabricated of beryllium copper and employ methanol as the working fluid. Testing of one heat pipe system for the SEM indicates that the cooled module may be operated at up to 20 watts total power dissipation without exceeding the critical component temperature of 100 C. Heat pipe card guides capable of interfacing with existing hardware and providing a heat transfer rate in the range of 500 to 600 watts have also been developed.

HP78 24012 DIRECT HEAT PIPE COOLING OF SEMI-CONDUCTOR DEVICES

Nelson, L.A., Sekhon, K.S., Fritz, J.E., (Hughes Aircraft Co., Fullerton, CA), 3rd Heat Pipe Conf. Tech. Papers, Palo Alto, CA, p. 373-376, May 22-24, 1978, AIAA, Inc., New York, NY, A78-35626

Avail:AIAA

A heat pipe system has been used to reduce by as much as 33 percent the thermal resistance from junction to case in a semi-conductor. Difficulties in utilizing heat pipes to cool transistor junctions include the physical problem of applying a wick to bring the working fluid in contact with the junction, the chemical problem of fluid-transistor material interactions, and the electrical interference that may be caused by the heat pipe. Development of fiber wicks and high-performance powder wicks for RF power transistors is given particular consideration.

HP78 24013 IMPROVED MIC PERFORMANCE THROUGH INTERNAL HEAT PIPE COOLING

Nelson, L.A., Sekhon, K.S., Fritz, J.E., (Hughes Aircraft Co., Fullerton, CA), Proc. of Tech. Program Nat'l Electron. Pkg. Prod. Conf., p. 441-447, Anaheim, CA, March 1-3, 1977, Philadelphia, PA, May 17-19, 1977, Publ. by Ind. and Sci. Conf. Manag., Chicago, IL

It is demonstrated that heat pipe cooling is an effective method of improving the cooling of MIC. The Hughes Powder Wick and heat pipe fluids are chemically, physically, and electrically compatible with the MIC and transistor chip and provides the required high performance and adaptability to production methods. The improved cooling available through heat pipe techniques can be used to improve the power, reliability, or efficiency of MIC's.

HP78 24014 USE OF TWO-PHASE TRANSFER FOR IMPROVED TRANSFORMER COOLING, Final Report

Saaski, E.; Franklin, J.L., Sigma Research, Inc., Richland, WA, 216 p., 1977

The potential for significantly improving transformer thermal performance by implementing new heat transfer technology was investigated. The investigation centered around two-phase heat transfer techniques and devices. Equipment was considered that was active (that is, consumed energy), as well as equipment that was passive. For power class transformers, for example, this included such devices as a forced-flow heat pipe, as well as a heat pump system in which a vapor compressor reduces the transformer oil temperature below that of ambient air. Cost comparisons were made for both systems, with the former appearing cost-competitive in forced air operation and the latter appearing cost-competitive in the thermal dissipation range of 20 to 200 KW. Additional effort was also directed toward studies of improved single-phase cooling systems for power transformers, including the development of a more precise technique for modeling thermosyphon flow and its application to the design of finned aluminum transformer radiators. The use of two-phase heat transfer techniques was considered in particular detail for applications where effective heat rejection is difficult using existing technology. For underground transformers, reflux condenser systems were considered as a means of increasing load capability. In particular, heat pipes linking the transformer to surrounding soil were found to be an optimal method of cooling. An additional benefit of this transformer cooling investigation was development of two possible methods of measuring core and coil temperatures. These methods and the design of the measuring equipment are discussed.

HP78 24015 EFFECT OF AN ELECTRICAL FIELD ON THE HEAT-TRANSMITTING CHARACTERISTICS OF A HEATING PIPE

Shkilev, V.D., Bologa, M.K., Marin, D.V., (Kishinev., USSR), Electron. Obrab. Mater., p. 61-64, 1977

No abstract available

HP78 24016 HEAT PIPES CUT SIZE OF HIGH-POWER SEMI-CONDUCTORS

Smoluk, G., Design News, V 33:64-65, N22, 1977

No abstract available

HP78 24017 INTENSIFICATION OF COOLING FOR LOW-VOLTAGE ENCLOSED INDUCTION MOTORS

Tubis, Y.B., Fanar, M.S., Sov. Electr. Engng., V 47:96-101, N10, 9 refs, 1976

Methods for intensifying cooling of induction motors through the use of heat-conducting fillers, heat pipes, and water are considered. Results of an experimental investigation are reported.

III. HEAT PIPE THEORY

III. A. GENERAL

HP78 30013 DESIGNING EVAPORATIVE THERMAL SIPHONS FOR USE IN THERMOELECTRIC DEVICES

Berdiev, M.G., (Dagestan Polytech. Inst., USSR), Appl Solar Energy, USSR, Engl. Transl., V 13:11-16, N2, 11 refs, 1977

Results are reported for experimental investigations aimed at validating computational relationships. A method of designing evaporative thermal siphons for thermoelectric instruments is proposed.

HP78 30014 TEMPERATURE AND HEAT LOAD DISTRIBUTION IN ROTATING HEAT PIPES

Daniels, T.C., Al-Baharnah, N.S., (Swansea Univ. College, Swansea, Wales), 3rd Heat Pipe Conf. Tech. Papers, Palo Alto, CA, p. 170-176, May 22-24, 1978, AIAA, Inc., New York, NY, A78-35600
Avail:AIAA

An analysis is proposed for predicting the condenser wall temperature profile showing the effect of functions such as concentration of noncondensable gases and type of working fluid, condenser wall material, and cooling medium. A prediction of the heat rejected ratio between a condenser operating with non-condensable gas present to that with pure vapor is given. The working fluids considered were arcton 113 and acetone and the non-condensable gases were nitrogen and carbon dioxide. The theoretical results obtained were checked with some experimental results using the above fluids and an agreement was obtained.

HP78 30015 LOW-TEMPERATURE HEAT PIPES WITH VAPOR INJECTION

Gerasimov, I.F., Kiseev, V.M., Maidanik, I.F., Dolgirev, I.E., (Ural'skii Politekhnicheskii Institut, Sverdlovsk, USSR), Inzhenerno-Fizicheskii Zhurnal, V 33:573-580, Oct. 1977, In Russian, A78-24151

The two heat pipe systems with a low-pressure injector, examined in the present paper, reduce appreciably the hydrostatic pressure of the liquid column without decreasing the distance of heat transfer. In one system, the low-pressure injector provides complete vapor condensation and makes the heat transfer agent circulate in a closed contour, thereby creating favorable conditions for operation in a gravitational field. In the other system, the injector atomizes the liquid column in the condensate line and circulates the heat transfer agent in the form of alternating liquid and vapor columns. The absence of a compact column reduced significantly the hydrostatic resistance in the motion of the condensate to the evaporization zone. The heat transfer characteristics of both systems are plotted for various operating conditions.

HP78 30016 DEVELOPMENT OF AN AXIAL GROOVE ALUMINUM/AMMONIA LIQUID TRAP HEAT PIPE THERMAL DIODE

Groll, M., Muenzel, W.D., Supper, W., (Stuttgart Universitaet, Stuttgart, W. Germany), Savage, C., (ESA, European Space Res. and Tech. Centre, Noordwijk, Netherlands), 3rd Heat Pipe Conf. Tech. Papers, Palo Alto, CA, p. 184-193, May 22-24, 1978, AIAA, New York, NY A78-35602
Avail:AIAA

An all-aluminum axial groove liquid trap heat pipe diode, 470 mm long and 10 mm O.D., has been developed with a forward-mode performance of nearly 90 wm, when ammonia is used as the working fluid at 20 C. The diode is bendable, of simple design and performance. A mathematical model, based on an energy balance for evaporator and trap, has been developed for predicting the transient shutdown of the diode. Theoretical predictions and experimental results are in good agreement. The time for complete shutdown of the diode is of the order of 20 min. The respective shutdown energy is about four whr. A reverse-mode heat flow of about 1.5 w has been measured. Thereby a shutdown ratio of about 300 has been established.

HP78 30017 ELECTRIC POWER GENERATION UTILIZING A HEAT PIPE TURBINE GENERATOR

Haapala, U.S., Hilding, W.E., (Univ. of Connecticut, Storrs, CT), Proc. of Inter-Am. Conf. on Materials Tech., 1975

A heat pipe is a self-contained and totally enclosed heat transfer device with internal two-phase flow. The phase change allows apparent thermal conductivities several thousand times greater than solid metallic conductors of similar cross-sectional area. Descriptive equations for the liquid and vapor transport and phase transformations occurring within the heat pipe have been given previously, therefore, only the constitutive equations for power availability in the adiabatic section are presented. It is concluded that (1)the power generation concept of a turbine-generator within the adiabatic section of a heat pipe is viable; (2)in order to provide acceptable levels of thermal efficiency, low internal vapor pressures must be maintained, such as less than two in hg with water as the working fluid; (3) the applicability of the concept would appear to be more attractive where sources of relatively cheaper thermal energy are available, such as solar energy or waste industrial thermal energy; (4) the ideal working fluid should possess low values of the heat of vaporization, high specific volume of its vapor phase, and low specific volume of its liquid phase.

HP78 30018 EFFECT OF THE AMOUNT OF COOLANT ON THE OPERATION OF HEAT PIPES WITH AN INHOMOGENEOUS CAPILLARY STRUCTURE IN THE ABSENCE OF BODY FORCES

Ivanovskii, M.N., Sorokin, V.P., Privezentsev, V.V., (Physicopower Inst., Obninsk, USSR), High Temp., V 15:736-741, N4, 2 refs, July-Aug. 1977

A study was made of the effect of the amount of coolant on the maximum transferred power of heat pipes. A method of calculating the allowable amount of underfilling of the heat pipe with coolant is proposed on the basis of a model of partial draining of the capillary structure.

HP78 30019 ANALYSIS OF AXIALLY GROOVED HEAT PIPE CONDENSERS

Kamotani, Y., (Goddard, NASA, Greenbelt, MD), Progr. Astronaut. Aeronaut., V 56:37-55, 1977

No abstract available

HP78 30020 EHD HEAT PIPE: THEORETICAL CONSIDERATIONS AND DESIGN

Kikuchi, K., Taketani, T., J. Mech. Engng. Lab., V 31:301-313, N6, 1977

No abstract available

HP78 30021 COST-EFFECTIVENESS STUDY OF HEAT PIPE HEAT EXCHANGERS

Lu, D.C., Feldman, K.T. Jr, (Univ. of New Mexico, Albuquerque, NM), ASME Winter Annual Mtg. Proc., Atlanta, GA, 7 p., Nov. 27-Dec. 2, 1977, A78-33171, Members, $1.50, Non-members, $3.00

The initial costs of three types of heat pipe heat exchangers are presented aluminum-freon 11 for the temperature range from -23 C to 121 C, copper-water for 38 C to 232 C, and carbon steel-dowtherm A for 120 C to 400 C. An optimization computer program for the cost-effectiveness analysis is developed, which takes into consideration the costs for equipment, installation, operation, and maintenance. An optimization example is given for a carbon steel-dowtherm A heat pipe heat exchanger designed to recover heat from the 8534 m^3/min of 316 C flue gas exhausting from the university heating plant boilers.

HP78 30022 PREDICTION OF EVAPORATOR TEMPERATURE OF A GAS-LOADED HEAT PIPE BY THE DIFFUSE FRONT MODEL

Shimoji, S., (Mitsubishi Electric Corp., Amagasaki, Japan), Kimura, H., (Mitsubishi Electric Corp., Kanagawa, Japan), Matsushita, T., (Nat'l Space Dev'ment Agency of Japan, Tokyo, Japan), 3rd Int. Heat Pipe Conf. Tech. Papers, Palo Alto, CA, p. 155-161, May 22-24, 1978, AIAA, Inc., New York, NY, A78-35598
Avail:AIAA

A new method of numerical analysis has been developed to aid in the design of a gas-loaded heat pipe. The method is capable of solving the diffuse front model of Edwards and Marcus for specified values of both heat input and non-condensable gas amount. The temperature of evaporator is precisely predicted. This method of iterative solution showed rapid convergence rates in most of calculations. The boundary condition, for the vapor velocity, which has influence on the predicted temperature distribution in the vapor front, is set to meet actual operations of the heat pipe. The calculated results showed good agreement with the confirmation experiment presented.

III. B. HEAT TRANSFER

HP78 31015 POLYSTYRENE AND POLYURETHANE FOAMS AT LOW TEMPERATURES

Hingst, U., (Dornier Systems, Friedrichshafen, Germany), Forsch Ingenieurwes, V 43:185-190, N6, 10 refs, 1977, In German

The heat conductivity of polystyrene foam was measured as a function of temperature (300 to 29 K), temperature difference, filling gas pressure, and emission coefficient of the edge plates. The heat transfer in foams by conduction, radiation, and convection is sufficiently investigated at ambient temperature and is represented by a well-known set of formulas. A comparison of the results predicted by these formulas with own measurements shows very good agreement excepting the region where the filling gas is condensed. In this region a very strong increase of heat conduction in the foam was found. The reason for this additional heat transfer is comparable with the mechanism of heat pipes. Using a simplified model of the structure, the governing parameters of the additional heat transfer are described. A method of calculation for these parameters is given. The results are compared with measurements of polyurethane foam.

HP78 31016 CALCULATION OF A HEAT PIPE OPERATING IN A FIELD OF MASS FORCES WHICH PREVENT TRANSPORT OF THE HEAT-TRANSFER AGENT TO THE EVAPORATION ZONE

Ivanovskii, M.N., Aptekar, B.F., (Gosudarstvennyi Komitet Po Ispol'zovaniiu Atomnoi Energii, Fiziko-Energeticheskii Institut, Obninsk, USSR), Teplofizika Vysokikh Temperatur, V 16:109-116, Jan.-Feb. 1978, In Russian

A mathematical model is proposed for a heat tube which employs a homogeneous wick and an essentially low-temperature heat-transfer agent, and which operated with a partially wetted wick in a field of mass forces. The calculation of heat-tube parameters is demonstrated by an example. It is shown that heat fluxes are much smaller in the presence than in the absence of a field of mass forces. The model proposed is seen to be well-suited for evaluating the heat-transfer characteristics of heat tubes and for extrapolating test data from conditions in the presence of a field of mass forces to conditions in the absence of the field.

HP78 31017 EVAPORATOR FILM COEFFICIENTS OF GROOVED HEAT PIPES

Kamotani, Y., (Case Western Reserve Univ., Cleveland, OH), 3rd Int. Heat Pipe Conf. Tech. Papers, Palo Alto, CA, p. 128-130, May 22-24, 1978, AIAA, Inc., New York, NY, A78-35594
Avail:AIAA

The heat transfer rate in the meniscus attachment region of a grooved heat pipe evaporator is studied theoretically. The analysis shows that the evaporation takes place mainly in the region where the liquid changes its shape sharply. However, comparisons with available heat transfer data indicate that the heat transfer rate in the meniscus varying region is substantially reduced probably due to groove wall surface roughness.

HP78 31018 METHOD FOR CALCULATING UNSTEADY CONVECTIVE HEAT TRANSFER IN CHANNELS OF NON-CIRCULAR CROSS-SECTION

Kochubei, A.A., Riadno, A.A., (Dnepropetrovskii Gosudarstvennyi Universitet, Dnepropetrovsk Ukrainian SSR), Teplofizika I Teplotekhnika, p. 79-83, N33, 1977, In Russian, A78-22540

The Kantarovich method (1962) and the method of characteristics are used to solve the unsteady boundary value problem of convective heat transfer in the steady flow of a viscuous incompressible fluid in a pipe of arbitrary cross-section. Temperature distribution is determined by integrating the energy equation; velocity profiles are determined by simultaneous solution of the equations of motion and continuity. The method used can be applied to pipes of elliptical, prismatic, rectangular, and other cross-section shapes for the case of laminar flow.

HP78 31019 AXIAL POWER LIMITS OF HEAT PIPES IN VERTICAL POSITION OPERATING WITH GRAVITY

Mojtabi, A., (CNRS, Aerotherm. Lab., 4 TER Route Des Gardes/F-92190 Meudon, France), Letters in Heat and Mass Transfer, V 5:141-148, N2, 1978

No abstract available

HP78 31020 HEAT AND MASS TRANSFER IN UNDEVELOPED BOILING IN HEAT-TRANSMITTING SLOT CHANNELS

Novikov, P.A., Lyubin, L.Y., Snezhko, E.K., (Lykov Inst. of Heat. and Mass Transfer, Acad. of Sci. of the BSSR), J. Eng. Phys., V 31:1423-1429, N6, 14 refs, Dec. 1976

A study is made of the use of narrow heat-transmitting slot channels filled with a subliming heat-transfer medium as ordinary heat pipes in which the role of the wick is played by the closed slot channels partially filled with liquid. In particular, the effectiveness of such heat-transmitting devices in the separation of the heat-transfer medium in the "hot" zone of a plant slot gap is considered.

HP78 31021 AN INVESTIGATION OF HEAT PIPE MENISCUS HEAT TRANSFER

Saaski, E.W., Franklin, J.L., (Sigma Res. Inc., Richland, WA), McCreight, C.R., (NASA, Ames, Moffett Field, CA), 3rd Int. Heat Pipe Conf. Tech. Papers, Palo Alto, CA, p. 131, 132, May 22-24, 1978, AIAA, Inc., New York, NY, A78-35595
Avail:AIAA

The use of grooved evaporator surfaces in heat pipes has increased in popularity in the past few years primarily due to the reproducibility achievable with grooved walls and the relatively low costs of the threading or extrusion processed involved in their production. The present study combines both analyses and experiments on square groove geometries, with special emphasis on overcoming the limitations of earlier analyses with finite-difference methods and groove-fillet hydrodynamic simplifications. The groove fillet, which has in previous analyses been assumed constant in radius of curvature, is permitted to change in thickness and curvature consistent with hydrodynamics and heat loss from the groove. A model is developed for accurate determination of the effect of constriction resistance on groove performance. The grooved-surface tests to be conducted are briefly described which will provide data under closely controlled operation to allow comparison and verification of the analyses.

HP78 31022 DYNAMIC CHARACTERISTICS OF DOUBLE-PIPE HEAT EXCHANGERS WITH DOUBLE PHASE CHANGE

Schult, M., Mayinger, F., (Der Technischen Universitat Hannover, Hannover, FRG), 98th Annual Winter Mtg. of ASME, Atlanta, GA, Nov. 27-Dec. 2, 1977, ASME, New York, NY
No abstract available

HP78 31023 INVESTIGATION OF HEAT TRANSFER IN LAMINAR FLOW OF LIGHT TAR IN AN IRREGULARLY SHAPED CHANNEL

Semena, M.G., Klimkin, Y.V., (Kiev Polytech. Inst. Ukrainian SSR), Heat Transfer Sov. Res., V 9:127-133, N2, 8 refs, March-April 1977
The application of heat pipes for tar melting equipment is considered. Experimental data on heat transfer in laminar flow of tar bitumen are presented. A multifactorial, multilevel experimental design was used. An interpolation equation for the heat transfer coefficient was obtained and the effect of variable viscosity on heat transfer in an irregularly shaped channel was estimated.

HP78 31024 AN A PROXIMATE METHOD FOR CALCULATING THE HEAT-TRANSFER AGENT FLOW RATE THRO GH A PLANE-PARALLEL, POROUS HEAT PIPE WICK

Shcherbakov, V.K., Semena, M.G., Sharaevskii, I.G., (Kievskii Politekhnicheskii Institut, Kiev, Ukrainian SSR), Teplofizika I Teplotekhnika, N29, p. 53-57, 1975, Heat Transfer-Sov. Res., V 9:114-119, March-April 1977, A78-30499
No abstract available

HP78 31025 THE HEAT TRANSFER BY BOILING IN SPLITS, CAPILLARIES, WICK STRUCTURES

Smirnov, G F., Koba, A.L., Afanasev, B.A., (Odessa Refrigeration Tech. Inst., Odessa, Ukrainian SR), 3rd Int. Heat Pipe Conf. Tech. Papers, Palo Alto, CA, 8 p., May 22-24, 1978, AIAA Inc., New York, NY, A78-35636
Avail:AIAA
The p ysical ideas of boiling in capillary-wick structures are proposed. Two main situations are studied: (1)boiling in capillary-wick structures bonded to a wall; and (2)boiling in capillary-wick structures separated from the wall. The analogy with pool boiling in the horizontal split is proposed for the latter situation. The methods and results of experimental investigations of pool boiling in horizontal splits and capillary-wick structures bounded to the wall are presented. The experimental data obtained by the authors and presented in the literature are generalized on the basis of proposed approximated models.

HP78 31026 HIGH-TEMPERATURE HEAT PIPES INVESTIGATION AT RADIAL HEAT TRANSFER

Tolubinskii, V.I., Shevchuk, E.N., Makarov, V.I., Tomashevskii, A.G., (Akademiia Nauk Ukrainskoi SSR, Institut Tekhnicheskoi Teplofiziki, Kiev, Ukrainian SSR), 3rd Int. Heat Pipe Conf Tech. Papers, Palo Alto, CA, p. 292-296, May 22-24, 1978, AIAA, Inc., New York, NY, A78-35616
Avail:AIAA
It is noted that the vapor channel caloric intensity of radially arranged heat pipes is almost two orders less than that of heat pipes arranged axially. The effect is due primarily to interactions between the evaporation and condensation surfaces. Attention is given to pipe dimensions and their influence on flow acceleration and friction loss. It is observed that heat pipes with radial heat transfer permit a sharp increase in the power transmitted under comparable effective radii of capillary menisca curvature, as well as simplifying start-up through simultaneous heating of the whole condensation surface.

HP78 31027 HEAT TRANSFER IN THE BOILING OF A LIQUID ON POROUS AND DEVELOPED HEATING SURFACES

Vasilev, L.L., Abramenko, A.N., Kanonchik, L.E., (Akademiia Nauk Belorusskoi SSR, Institut Teplo I Massobmena, Minsk, Belorussian SSR), Inzhenerno-Fizicheskii Zhurnal, V 34:741-761, April 1978, In Russian, A78-35094
The present paper is a brief review of theoretical and experimental results obtained by various investigators of pool boiling heat transfer from porous capillary surfaces and from surface covered with a capillary network. The topics covered include the results of an analysis of a high-heat-flux water heat pipe evaporator; the use of thin films for increasing evaporation and condensation rates; data on the stability of boiling heat transfer; and data on vaporization heat transfer in capillary heat pipe wicks.

III. C. FLUID FLOW

HP78 32004 AXIALLY GROOVED HEAT PIPE STUDY

(B and K Engng., Inc., Towson, MD), NASA-CR-156678, BK012-1009, NAS5-22562, 103 p., 1977, N78-16317/7SL

A technology evaluation study on axially grooved heat pipes is presented. The state-of-the-art is reviewed and present and future requirements are identified. Analytical models, the groove analysis program (GAP) and a closed-form solution, were developed to facilitate parametric performance evaluations. GAP provides a numerical solution of the differential equations which govern the hydrodynamic flow. The model accounts for liquid recession, liquid-vapor shear interaction, puddle flow, as well as laminar and turbulent vapor flow conditions. The closed form solution was developed to reduce computation time and complexity in parametric evaluations. It is applicable to laminar and ideal charge conditions, liquid-vapor shear interaction, and an empirical liquid flow factor which accounts for groove geometry and liquid recession effects. The validity of the closed-form solution is verified by comparison with GAP predictions and measured data.

HP78 32005 THE DRY-OUT LIMITS OF GRAVITY-ASSIST HEAT PIPES WITH CAPILLARY FLOW

Busse, C.A., (Euratom and Comitato Nazionale per L'Energia Nucleare, Centro Comune di Ricerche, Ispra, Italy), Kemme, J.E., (Univ. of California, Los Alamos, NM), 3rd Int. Heat Pipe Conf. Tech. Papers, Palo Alto, CA, p. 41-48, May 22-24, 1978, AIAA, Inc., New York, NY, A78-35583
Avail:AIAA

Dry-outs of two different kinds can occur in gravity-assist heat pipes with capillary flow. An excess of hydrostatic driving force can lead to a receding of the menisci into the capillary structure and an "azimuthal dry-out" characterized by a concentration of the liquid flow on the lower part of the circumference of the heat pipe. The azimuthal dry-out most likely occurs during start-up and disappears at higher heat fluxes. It can be prevented by using a graded capillary structure or a homogeneous capillary structure with a static capillary rise, which exceeds the highest point of the evaporator. A lack of hydrostatic driving force, on the other hand, leads to an "axial dry-out," which is characterized by a lack of axial liquid return. If the heat pipe has a liquid pool at the bottom, the reaching of the axial dry-out limit in the capillary flow mode will manifest itself as the beginning of a pool transfer and an eventual transition to a new stationary state with mixed capillary and free flow. The basic equation for the axial dry-out is derived and resolved for a simple case. The role of inertia forces and entrainment is pointed out.

HP78 32006 THE SUPERSONIC FLOW OF VAPOR IN THE CONDENSATION ZONE OF HIGH-TEMPERATURE HEAT PIPES

Bystrov, P.I., Popov, A.N., (Akademiia Nauk SSSR, Moscow, USSR), 3rd Int. Heat Pipe Conf. Tech. Papers, Palo Alto, CA, p. 21-26, May 22-24, 1978, AIAA, Inc., New York, NY, A78-35580
Avail:AIAA

A calculation procedure is developed for the supersonic flow of vapor in the condensation zone of high-temperature heat pipes. The equations account for compressibility, friction, vapor velocity profile, non-uniform mass suction, and temperature dependence. Vapor state is described by an equilibrium two-phase flow model. The method is tested for a supersonic vapor flow in sodium heat pipes with various cooling intensities. Good agreement is found between calculation results and experimental data.

HP78 32007 SHOCK WAVES IN THE VAPOR FLOW OF HEAT PIPES

Bystrov, P.I., Popov, A.N., Teplofizika Vysokikh Temperatur, V 16:137-142, Jan.-Feb. 1978, In Russian, A78-32714

A method is proposed for calculating supersonic vapor flows and shock waves in the condensation zone of a heat pipe on the basis of equations of motion averaged with respect to the channel cross-section. The equations take into consideration the real velocity profile, the compressibility and friction of the vapor flow, and the non-uniformity of heat release. An equilibrium two-phase model is used to describe the state of the vapor. Diagrams showing the distribution of the vapor parameters along the length of a sodium heat pipe are discussed.

HP78 32008 GAS-INTERFACE STUDIES IN LARGE HORIZONTAL HEAT PIPES

Deverall, J.E., LASL, Los Alamos, NM), ERDA Energy Res. Abstr., 16p., 1977

No abstract available

HP78 32009 HIGH PERFORMANCE, HIGH TEMPERATURE HEAT PIPES

Eastman, G.Y., Ernst, D.M., (Thermacore, Inc., Leola, PA), 3rd Int. Heat Pipe Conf. Tech. Papers, Palo Alto, CA, p. 268-273, May 22-24, 1978, AIAA, Inc., New York, NY, A78-35613
Avail:AIAA

Mathematical models are contrasted with empirical data in an effort to design heat pipes using high performance wick structures. Objectives are an input power density of 100 w/cm^2 and an axial power density of 10,000 w/cm^2, with an operating temperature of up to 1600 C. Attention is given to the performance of fine pore powder metal wicks with integral low loss liquid flow passages (both alkali and integral metal working fluids). Laminar and turbulent flow parameters are also considered as a function of performance.

HP78 32010 THE MARANGONI EFFECT AND CAPACITY DEGRADATION IN AXIALLY GROOVED HEAT PIPES

Eninger, J.E., Marcus, B.C., (TRW Defense and Space Systems Group, Redondo Beach, CA), 3rd Int. Heat Pipe Conf. Tech. Papers, Palo Alto, CA, p. 414-417, May 22-24, 1978, AIAA, Inc., New York, NY, A78-35633
Avail:AIAA

The Marangoni effect is proposed as the primary mechanism responsible for the observed capacity degradation in gas-loaded variable-conductance axially grooved heat pipes. The temperature-induced surface-tension gradient in the gas-blocked portion of condenser drives a recirculatory flow. The pressure drop associated with it subtracts from the capillary pressure available to drive the condensate return in the active region. A mathematical model is presented and the results are compared to experimental measurements.

HP78 32011 MATHEMATICAL MODELING OF CURRENT DISTRIBUTION PROCESSES IN COMPLEX NON-LINEAR CIRCUITS

Groz, S.M., Maksimeniuk, I.A., Chelabchi, V.N., (Kiev, Institut Matematiki an USSR), Solution of Boundary Value Problems by Means of Mathematical Modeling, p. 88-91, 1976, In Russian, A78-25582

No abstract available

HP78 32012 ENTRAINMENT LIMITS IN HEAT PIPES

Tien, C.L., Chung, K.S., (Univ. of California, Berkeley, CA), 3rd Int. Heat Pipe Conf. Tech. Papers, Palo Alto, CA, p. 36-40, May 22-24, 1978, AIAA, Inc., New York, NY, A78-35582
Avail:AIAA

The present work explores the physical basis for the entrainment limit in heat pipes and attempts to develop adequate quantitative criteria for the limit. Analogy is emphasized here between the entrainment phenomenon in heat pipes and the flooding phenomenon in counter-current vapor-liquid flow systems. The maximum operating heat transfer rates for various heat pipes due to entrainment limitation are established semi-empirically by way of modifying existing flooding correlations. While the present results are successful in correlating the limited experimental data available, further experimental studies are needed in assessing the validity of the established criteria.

HP78 32013 NUMERICAL CALCULATIONS ON THE VAPOR FLOW IN A FLAT-PLATE HEAT PIPE WITH ASYMMETRICAL BOUNDARY CONDITIONS

Van Ooijen, H., Hoogendoorn, C.J., (Delft, Technische Hogeschool, Delft, Netherlands), 3rd Int. Heat Pipe Conf. Tech. Papers, Palo Alto, CA, p. 27-35, May 22-24, 1978, AIAA, Inc., New York, NY, A78-35581
Avail:AIAA

Steady laminar incompressible two-dimensional flow in a horizontal flat-plate heat pipe with an adiabatic top plate was studied. For uniform evaporation and condensation rates, the Navier-Stokes equations and the continuity equation were solved. For radial Reynolds numbers greater than one, the velocity profiles were non-similar and asymetrical. At radial Reynolds numbers greater than 10, backflow was observed along the top plate starting at the end of the condensation zone. At the highest radial Reynolds number, 50, the total pressure drop over the heat pipe was more than three times the value found from Poiseuille approximation. However, complete recovery of impulse pressure was found and the additional pressure losses could be fully attributed to increased frictional losses. Experiments with a porous-plate model showed excellent agreement.

HP78 32014 HEAT PIPES AND THEIR USE IN TECHNOLOGY

Vasilyev, L., (NASA, Washington, D.C.), Inzh. Fiz. Zh., USSR, V 31:905-907, N5, Nov. 1976, N78-13357/1SL

Heat pipes may be employed as temperature regulators, heat diodes, transformers, storage batteries, or utilized for transforming thermal energy into mechanical, electric, or other forms of energy. General concepts were established for the analysis of the transfer process in heat pipes. A system of equations was developed to describe the thermodynamics of steam passage through a cross-section of a heat pipe.

IV. DESIGN, DEVELOPMENT, AND FABRICATION

IV. A. GENERAL

HP78 40010 A RE-ENTRANT GROOVE HYDROGEN HEAT PIPE

Alarid, J., Kosson, R., McCreight, C., (Grumman Aerospace Corp., Bethpage, NY), (NASA, Ames, Moffett Field, CA), 3rd Int. Heat Pipe Conf. Tech. Papers, Palo Alto, CA, p. 194-202, May 22-24, 1978, AIAA, Inc., New York, NY, A78-35603
Avail:AIAA

This paper extends the development of re-entrant groove technology to hydrogen heat pipes. Parametric analyses are presented which optimize the theoretical design while considering the limitations of state-of-the-art extrusion technology. Acceptable production-type runs of extruded lengths (over 300 m) could only be achieved at the expense of a wider nominal groove opening than specified (0.33 mm vs. 0.20 mm). However, dimensional variations of other critical dimensions were within 0.05 mm, which exceeded expectations. The 6063-T6 aluminum extrusion is 14.6 mm OD with a wall thickness of 1.66 mm and contains 20 axial grooves which surround a central 9.3-mm-diam. vapor core. Each axial groove is 0.775-mm-diam. with a 0.33 mm opening. An excess vapor reservoir is provided at the evaporator to minimize the pressure containment hazard during ambient storage. Details of the instrumentation and helium-cooled test installation are also presented.

HP78 40011 HEAT PIPE MATERIALS COMPATIBILITY EXTENDED REPORT

Antoniuk, D., Luedke, E., (TRW, Redondo Beach, CA), (NASA, Lewis, Cleveland, OH), TRW sales no. 31132.00, NASA Contract no. NAS 3-20872, Dec. 1977
Avail:TAC

The second phase of an experimental program that lasted 32 months to evaluate non-condensable gas generation in ammonia heat pipes has been completed by TRW Defense and Space Systems Group. Forty-two heat pipes made of aluminum, stainless steel, or combinations of those materials were operated at different temperatures and lengths of time, and tested at temperatures ranging from -30 C to 10 C to quantitatively determine gas generation rates. In order of increasing stability are aluminum/stainless steel combination, all-aluminum and all-stainless steel solvent-cleaned heat pipes. It is concluded that solvent-cleaning for both all-aluminum and all-stainless steel heat pipes yields lower long-term gas generation than chemical cleaning.

HP78 40012 HEAT PIPE CAPABLE OF OPERATING AGAINST GRAVITY AND STRUCTURES UTILIZING SAME

Basiulis, A., US Patent no. 4,057,963, Nov. 15, 1977
Avail:Patent Office

A heat pipe has its evaporator at its upper end and its condenser at its lower end, and an adiabatic section separating the two so that capillary wicks or grooves do not extend through the heat pipe. A central liquid return tube extends between the evaporator and condenser. A vapor bubble generator is placed at the condenser section in the reservoir where the liquid state of the working fluid collects. When the vapor bubble generator is operated, bubbles form which, because of their buoyancy, will rise to the top of the central tube. As they rise, small amounts of working fluid in its liquid state will be carried with the bubbles and spill over the top of the tube and onto the evaporator wick. As a consequence, the heat pipe is insensitive to its vertical height and can operate against gravitational forces.

HP78 40013 PRECISION TEMPERATURE CONTROL WITH GAS - BUFFERED WATER HEAT PIPES

Bassani, C., Loens, J., (Euratom and Comitato Nazionale Per L'Energia Nucleare Centro Comune di Ricerche, Ispra, Italy), 3rd Int. Heat Pipe Conf. Tech. Papers, Palo Alto, CA, p. 162-166, May 22-24, 1978, AIAA, Inc., New York, NY, A78-35599
Avail:AIAA

Studies are reported on the improvement of the temperature control of gas-buffered heat pipe thermostats. Previously observed pressure fluctuations were eliminated by use of a lighter buffer gas. An automatic pressure control system was developed, which allows to maintain temperature stability to within ± 0.001 C/day at an operating temperature of 100 C. A new thermostatic heat pipe was built to reduce gas solution and impurity effects the thermostatic zone was placed at the far side of the heating zone with respect to the gas buffer, a purging valve was incorporated for eliminating any accumulated gas in the thermostatic zone, and an auxiliary condenser was provided for rinsing continuously the surface of the thermostatic chamber with fresh condensate. Temperature differences along the axis of the heat pipe were measured with an improved probe technique with a sensitivity of 0.00005 C. The first measurements confirmed the existance of two temperature plateaus of different levels at both sides of the heating zone. The temperature homogeneity of the thermostatic zone 60 cm long was in general of the order of 0.001. The best obtained temperature homogeneity was 0.0002 C.

HP78 40014 COAXIAL METALLURGICAL JUNCTION, ESPECIALLY FOR THERMIONIC CONVERTERS, SPECIAL FURNACES IN THE VACUUM TECHNIQUE

Belicic, M., German (FRG) Patent no. 2,347,203, Nov. 25, 1976, In German

The metallic joining of coaxial pipes with bolts or pipes by welding brings difficulties if the parts have different coefficients of thermal expansion and are subjected to an additional thermal cyclic loading. For such a case, the inventor suggests to provide the external pipe, and if necessary, the internal pipe with coaxial slots. This may help to reduce the dangerous radial tension. The slots are staggered between the internal and the external pipe diameter. The joints may be welded normally or brazed normally maintaining the width of the slots. Overlapping rings or expanding mandrels are provided for the maintenance of the pipe rigidity.

HP78 40015 HEAT TRANSFER EQUIPMENT

Brost, O., Schubert, P., Groll, M., Zimmerman, P., German (FRG) Patent no. 2,350,980/B, Nov. 18, 1976, In German

For a heat transfer facility, a so-called gas-stabilized heat pipe, an improvement is described which shall guarantee that control of the operational temperature will be possible with high accuracy, independent of the direction of heat transport. It is characterized by a connecting pipe originating at the gas reservoir, passing through the chamber in axial direction, and being provided with openings in the range of the cooling as well as the heating pipes. It is of advantage to provide the inner walls of the connecting pipe, as well as the gas reservoir with a capillary structure.

HP78 40016 ALASKA LINE DEVELOPS NEW TECHNOLOGY

Congram, G.E., Oil Gas J., V 75:95-96, 101-102, 104, 109-111, N43, Nov 21, 1977

Significant developments and techniques used in the design and construction of the Trans-Alaska Pipeline are highlighted. Some of these methods were used to insure structural integrity of the pipeline and its necessary supporting equipment. Others were designed to protect both the pipeline and the Alaskan frontier environment and its inhabitants. Special considerations were given to heat pipes to maintain permafrost in a stable condition, cathodic protection to prevent corrosion, and installation of gate and check valves for assuring the operating integrity and protection of natural resources and the environment.

HP78 40017 A LARGE-SCALE HEAT EXCHANGER WITH POLYGONALLY CONFIGURATED HEAT PIPE UNITS

Koizumi, T., Furuya, S., Matsumoto, K., Karawawa, K., (Furukawa Electric Co., Ltd., Tokyo, Japan), 3rd Int. Heat Pipe Conf. Tech. Papers, Palo Alto, CA, p. 76-79, May 22-24, 1978, AIAA, Inc., New York, NY, A78-35588
Avail:AIAA

A large-scale heat exchanger with polygonally configurated heat pipe units is proposed for heat recovery system with large gas flow rate. The length of a heat pipe is restricted by the maximum heat transfer limit and the limit of fabrication, and therefore, the height/width ratio of the face area becomes unbalanced if the heat pipes are arranged in traditional rectangular prism configuration. This makes the installation space unfavorably large and unsymmetrical, and then ducting work also becomes much more difficult. The problem can be resolved by introducing a novel arrangement of heat pipe elements in polygonal configuration. This paper describes outline of the large heat exchanger, some design examples and experimental results of a model heat exchanger with hexagonally configurated heat pipe units.

HP78 40018 A VARIABLE CONDUCTANCE HEAT PIPE FOR TERRESTRIAL APPLICATIONS

Molt, W. (Dornier System GMBH, Friedrichshafen, W. Germany), 3rd Int. Heat Pipe Conf. Tech. Papers, Palo Alto, CA, p. 10-14, May 22-24, 1978, AIAA, Inc., New York, NY, A78-35578
Avail:AIAA

A new type of variable conductance heat pipe, the liquid controlled heat pipe (LCHP), has been developed. While the gas controlled heat pipe is able to stabilize the temperature of the cooling zone to a certain adjustable value. The physical principle is to regulate the heat transfer capability by regulating the amount of liquid inside the heat pipe. The liquid partly stored in a reservoir with a variable volume, as for example, a bellows. The temperature of the cooling zone, corresponding to the vapor pressure (gas or spring) on the bellows. The LCHP is applicable where heat is needed at a constant temperature or where the vapor pressure inside a heat pipe has to be limited.

HP78 40019 GAS FILLED SWIVEL JOINT FOR CRYOGENIC HEAT PIPES

Novoryta, R.J., Dawson, F.W., US Patent no. 4,069,864, Jan. 24, 1978
Avail:Patent Office

In a vacuum environment such as space, conductive ball and socket members are fixed to respective heat pipes for permitting orthogonal movement of one heat pipe relative to the other and the gap between the ball and socket members is maintained under a light gas pressure with the low-pressure gas forming a low thermal impedence path across the gap.

HP78 40020 HIGH TEMPERATURE HEAT PIPES FOR TERRESTRIAL APPLICATIONS

Ranken, W.A., Lundberg, L.B., (Univ. of California, Los Alamos, NM), 3rd Int. Heat Pipe Conf. Tech. Papers, Palo Alto, CA, p. 283-291, May 22-24, 1978, AIAA, Inc., New York, NY A78-35615
Avail:AIAA

A high-temperature heat pipe design is described in which ceramic tubing is used to provide the basic structure and containment. The interior wall of this tubing is lined with a chemically vapor deposited metallic layer to protect the ceramic from the the alkali metal working fluid and furnish a distributive wicking surface. High temperature brazes and ceramic bonding agents are used to seal the assembly. The results of a program to develop such a unit for application to high temperature recuperators are discussed and potential applications to coal conversion and coal utilization systems are reviewed.

HP78 40021 MULTI-CHAMBER CONTROLLABLE HEAT PIPE

Shlosinger, A.P., (NASA, Ames, Moffett Field, CA), US Patent no. 3,543,839, 8 p., 1969, N78-17337/4SL
Avail:Patent Office

A temperature controllable heat pipe switching device is reported. It includes separate evaporating and condensing chambers interconnected by separate vapor flow and liquid return conduits. The vapor flow conduit can be opened or closed to the flow of vapor, whereas the liquid return conduit blocks vapor flow at all times. When the vapor flow path is open, the device has high thermal conductivity, and when the vapor flow path is blocked, the device has low thermal conductivity.

HP78 40022 HEAT PIPE WITH DUAL WORKING FLUIDS

Shlosinger, A.P., (NASA, Ames, Moffett Field, CA), Patent supersedes PAT-APPL-42 088-70, 6 p., 1970, N78-17336/6SL
Avail:Patent Office, $0.50

A heat pipe design is offered that utilizes an auxiliary working fluid. The fluid, although being less efficient than the main working fluid, remains liquid at low heat loads when the main working fluid freezes.

IV. B. WICKS

HP78 41006 COMPLEX INVESTIGATION OF CHARACTERISTICS AND PROCESSES IN ARTERY-GROOVED HEAT PIPES

Chaikovskii, V., Smirnov, G., Burdo, O., Smirnova, J., Iaroshevich, I., (Odessa Technological Institute of Food Industry, Odessa, Ukrainian SSR), 3rd Int. Heat Pipe Conf. Tech. Papers, Palo Alto, CA, p. 426-433, May 22-24, 1978, AIAA, Inc., New York, NY A78-35635
Avail:AIAA

The effective thermal conductivity of grooved capillary structures of triangular and rectangular shapes within the range of liquid-phase/metal thermal conductivities from 0.1 to 0.001 has been investigated with the help of the electrothermal analogy method. The dependences for calculating the effective conductivity of such structures under the conditions of evaporation and condensation have been obtained. The thermal model was based on the superposition principle of separate thermal resistances. The estimated values are in good agreement with experimental data obtained for a flat heat pipe. The results permitted optimization of the parameters of cooling systems with heat pipes.

HP78 41007 DEVELOPMENT OF AN AXIALLY GROOVED HEAT PIPE WITH NON-CONSTANT GROOVE WIDTH

Schlitt, K.R., (ERNO Raumfahrttechnik GMBH, Bremen, W. Germany), 3rd Int. Heat Pipe Conf. Tech. Papers, Palo Alto, CA, p. 1-9, May 22-24, 1978, AIAA, Inc., New York, NY, A78-35577
Avail:AIAA

The paper presents a new concept of an axially grooved heat pipe, which is composed of two or three pipe sections with different groove dimensions to increase wick permeability. The result is a wick design with graded porosity character and high heat transport capability. According to test results, which compare favorably with predicted data, heat transport of the new heat pipe is three times larger than in comparable conventional designs. This improvement is partly due to the graded porosity wick design and partly due to avoiding shear interaction between vapor and liquid. In addition to the constant conductance mode, the concept may be also effectively used for a liquid trap thermal diode design. Potential applications for the new design have been defined in spacelab utilization programs and future high power communication and scientific space-raft projects.

HP78 41008 STUDY OF THE EFFECTIVE THERMAL CONDUCTIVITY OF METALLOFIBROUS WICKS OF LOW-TEMPERATURE HEAT PIPES

Semina, M.G., Zaripov, V.K., Inzh. Fiz. Zh., V 33:255-262, 1977

No abstract available

HP78 41009 APPROXIMATE METHOD FOR CALCULATING THE HEAT-TRANSFER AGENT FLOWRATE THROUGH A PLANE-PARALLEL POROUS HEAT-PIPE WICK

Scherbakov, V.K., Semena, M.G., Sharayevskiy, I.G., (Kiev Polytech. Inst., Ukrainian SSR), Heat Transfer Sov. Res., V 9:114-119, N2, 5 refs, March-April 1977

An approximate method for determining the flowrate of the heat transfer agent through a plane-parallel porous heat pipe wick is analyzed. The rate of heat transfer agent absorption on the wick surface is determined by methods of pressure under pressure.

HP78 41010 APPROXIMATE THEORY OF HEAT TRANSFER OF LIQUIDS BOILING ON SURFACES COVERED WITH CAPILLARY POROUS STRUCTURES

Smirnov, G., (Odessa Tech. Inst. of Refrigerating Ind., Ukrainian SSR), Teploenergetika, p. 77-80, N9, 11 refs, Sept. 1977, In Russian

The mechanisms of heat transfer of liquids boiling in capillary-porous structures fixed to a wall is considered. Such structures are utilized in heat pipes of different designs: vapor chambers and special heat exchangers.

HP78 41011 HEAT TRANSFER AT LIQUID EVAPORATION FROM WICKS CAPILLARY STRUCTURE OF LOW TEMPERATURE HEAT PIPES

Tolubinskii, V.I., Antonenko, V.A., Ostrovskii, I.N., Shevchuk, E.N., (Akademiia Nauk Ukrainskoi SSR, Institut Tekhnicheskoi Teplofiziki, Kiev, Ukrainian SSR), 3rd Int. Heat Pipe Conf. Tech. Papers, Palo Alto, CA, p. 140-146, May 22-24, 1978, AIAA, Inc., New York, NY, A78-35596

Avail:AIAA

No abstract available

IV. C. MATERIALS

HP78 42003 RELIABILITY OF LOW-COST LIQUID METAL HEAT PIPES

Ewell, G.J., Basiulis, A., Lamp, T.R., (Hughes Aircraft Co., Torrance, CA), 3rd Int. Heat Pipe Conf. Tech. Papers, Palo Alto, CA, p. 297-302, May 22-24, 1978, AIAA, Inc., New York, NY, A78-35617

Avail:AIAA

Low-cost stainless steel heat pipes containing sodium or potassium working fluids have been proven to have long-term reliability. Heat pipes fabricated from 304 stainless steel with wicks of the same material have exhibited over 10,000 hours of reliable operation at 600 C (potassium) and 700 C (sodium) in ambient environments. Temperature stability was maintained to within 5 C over the test period. Extensive metallurgical analyses of inner and outer surfaces of the heat pipes and of the wicks have shown only minor amounts of material transport and of leaching from inner surfaces. External oxidation was negligible and there were no indications of electrolytic corrosion. The depth of inner surface attack was only 0.001 to 0.003 cm in thickness after 10,000 hours of operation. From this information lifetimes in excess of 50,000 hours can be reliably predicted.

HP78 42004 USE OF REFRACTORY METALS WITH ADDITIVES IN OXYGEN STABILIZING ELEMENTS AS WALL MATERIALS FOR HEATER TUBES

Kraft, G., Poetzschka, M., Busse, C., Geiger, F., German (FRG) Patent no. 1,751,411/C, Nov. 4, 1976, In German

Premature destruction by corrosion of wall materials for heat conducting tubes for high temperatures is prevented by using refractory metals, such as niobium, tantalum, zirconium (to a lesser extent molybdenum and tungsten). Such tubes are used, for example, in thermionic energy converters at temperatures of 1400 to 1600 C. Lithium is mainly used as the evaporating and condensing coolant in the circuit. Alloys such as niobium with one percent zirconium and tantalum with five percent tungsten can be considered for walls, apart from pure refractory metals. Five to 500 pp. yttrium or cerium or lathanum are added as oxygen stabilizing elements. This reduces the velocity of diffusion of the oxygen in the wall material to such an extent that the continuously flowing filling material can dissolve practically no oxygen or deposit the corresponding oxide in the combustion zone. A heat-conducting tube of metal having a composition according to the invention has survived for 1000 hours of operation at 1600 C and with axial heat flow densities of over 10 kw cm^{-2}. This had no adverse effect on the capillary structure of the inner tube wall.

HP78 42005 COMPATIBILITY TESTS OF VARIOUS HEAT PIPE WORKING FLUIDS AND STRUCTURAL MATERIALS AT DIFFERENT TEMPERATURES

Muenzel, W.D., (Stuttgart Universitaet, Stuttgart, W. Germany), 3rd Int. Heat Pipe Conf. Tech. Papers, Palo Alto, CA, p. 96-101, May 22-24, 1978, AIAA, Inc., New York, NY, A78-35591
Avail:AIAA
No abstract available

V. TESTING AND OPERATION

HP78 50016 TEST REPORT FOR HEPP/LDEF AXIALLY GROOVED HEAT PIPE

(B & K Engng., Inc., Towson, MD), (NASA, Ames, Moffett Field, CA), NASA contract no. NAS2-9613, BK042-1011, 9 p., June 1978
Avail:TAC

This report presents a summary of thermal performance test results that were obtained with a stainless steel axially grooved liquid trap diode heat pipe. The heat pipe configuration was designed for possible application in the HEPP/LDEF low temperature heat pipe experiment. Ethane was used as the working fluid for nominal operation at 180 K. Start-up and recovery behavior was observed, as well as the determination of forward mode transport and reverse mode shutdown characteristics. Tests were also conducted at 150 K.

HP78 50017 SUMMARY REPORT FOR AN INVERTED ARTERY HEAT PIPE

(B & K Engng., Inc., Towson, MD), (NASA, Lewis, Cleveland, OH), P.O. no. C-6628-D, BK043-1001, 19 p., April 1978
Avail:TAC

This report presents the theoretical analysis and test results for an inverted artery heat pipe that was designed by NASA Lewis Research Center. The heat pipe contains eight inverted channels as the primary wick and utilizes screw thread grooves for circumferential distribution of the liquid. A series of tests were run to determine the transport capability of the heat pipe at various elevations. Results are also presented which show the reduction in heat transport capability when non-condensable gas is present in the heat pipe.

HP78 50018 FLEXIBLE CRYOGENIC HEAT PIPE DEVELOPMENT PROGRAM, Final Report

(Rockwell Int. Corp., Downey, CA, Space Div.), July, 1976
Avail:NTIS

A heat pipe was designed for operation in the 100 to 200 K temperature range with maximum heat transport as a primary design goal. Another designed for operation in the 15 to 100 K temperature range with maximum flexibility as a design goal. Optimum geometry and materials for the container and wicking systems were determined. The high power (100 to 200 K) heat pipe was tested with methane at 100 to 140 K, and test data indicated only partial priming with a performance limit of less than 50 percent of theoretical. A series of tests were conducted with ammonia at approximately 230 K to determine the performance under varying fluid charge and test conditions. The low temperature heat pipe was tested with oxygen at 85 to 95 K and with methanol at 295 to 315 K. Performance of the low temperature heat pipe was below theoretical predictions. Results of the completed testing are presented and possible performance limitation mechanisms are discussed. The lower-than-expected performance was felt to be due to small traces of non-condensable gases which prevented the composite wick from priming.

HP78 50019 HEAT PIPE MATERIALS COMPATIBILITY EXTENDED REPORT

Antoniuk, D., Luedke, E., (TRW, Redondo Beach, CA), (NASA, Lewis, Cleveland, OH), TRW sales no. 31132.00, NASA Contract no. NAS 3-20872, Dec. 1977
Avail:TAC

The second phase of an experimental program that lasted 32 months to evaluate non-condensable gas generation in ammonia heat pipes has been completed by TRW Defense and Space Systems Group. Forty-two heat pipes made of aluminum, stainless steel, or combinations of those materials were operated at different temperatures and lengths of time, and tested at temperatures ranging from -30 C to 10 C to quantitatively determine gas generation rates. In order of increasing stability are aluminum/stainless steel combination, all-aluminum and all-stainless steel solvent-cleaned heat pipes. It is concluded that solvent-cleaning for both all-aluminum and all-stainless steel heat pipes yields lower long-term gas generation than chemical cleaning.

HP78 50020 HEAT PIPE MIRRORS FOR HIGH POWER LASERS

Barthelmy, R., Jackson, D., Rabe, D., (Air Force Aero. Propul. Lab., Wright-Patterson AFB, OH), ASME Mtg. Paper no. 78-HT-60, 3 p., 5 refs, May 24-26, 1978

The design, test, and analysis of cylindrical copper-water heat pipe mirrors for applications in high power lasers were conducted. Testing of the heat pipe mirror determined its ability to reduce thermal distortions in comparison with water cooled and uncooled mirrors. Three types of energy sources were used for testing: a carbon arc solar simulator, an electron beam, and a laser beam. With the ten kilowatt carbon arc solar simulator, heat inputs absorbed by the two-in diameter heat pipe mirror of 350 watts/cm^2 were measured. During the in-vacuo, electron beam experiments, surface distortions were measured through holographic interferometry. Similar experiments were conducted on a high power carbon dioxide laser. The test mirror was placed in an interferometer and simultaneously irradiated with a laser beam of 1000 watts/cm^2 over a 7.5 cm^2 area. Changes on the mirror surface indicate that heat pipe mirrors are the most practical for high power laser applications.

HP78 50021 PRECISION TEMPERATURE CONTROL WITH GAS - BUFFERED WATER HEAT PIPES

Bassani, C., Loens, J., (Euratom and Comitato Nazionale Per L'Energia Nucleare Centro Comune di Ricerche, Ispra, Italy), 3rd Int. Heat Pipe Conf. Tech. Papers, Palo Alto, CA, p. 162-166, May 22-24, 1978, AIAA, Inc., New York, NY, A78-35599
Avail:AIAA

Studies are reported on the improvement of the temperature control of gas-buffered heat pipe thermostats. Previously observed pressure fluctuations were eliminated by use of a lighter buffer gas. An automatic pressure control system was developed, which allows to maintain temperature stability to within ± 0.001 C/day at an operating temperature of 100 C. A new thermostatic heat pipe was built to reduce gas solution and impurity effects the thermostatic zone was placed at the far side of the heating zone with respect to the gas buffer, a purging valve was incorporated for eliminating any accumulated gas in the thermostatic zone, and an auxiliary condenser was provided for rinsing continuously the surface of the thermostatic chamber with fresh condensate. Temperature differences along the axis of the heat pipe were measured with an improved probe technique with a sensitivity of 0.00005 C. The first measurements confirmed the existance of two temperature plateaus of different levels at both sides of the heating zone. The temperature homogeneity of the thermostatic zone 60 cm long was in general of the order of 0.001. The best obtained temperature homogeneity was 0.0002 C.

HP78 50022 INTENSITY OF HEAT TRANSFER AT THE BOILING SECTION OF EVAPORATIVE THERMOSIPHONS

Bezrodnyi, M.K., Alekseenko, D.V., (Kiev Polytech. Inst., Ukrainian SSR), Teploenergetika, p. 83-85, N7, 16 refs, July 1977, In Russian

Results are presented of an experimental investigation of heat transfer of boiling liquids in closed two-phase coreless heat pipes (thermosiphons), depending on their geometrical dimensions, the type of the working fluid, and pressure in the inner cavity. The experiments are carried out on water, ethanol, methanol, freon 11, and freon 113. As a result of the investigation and generalization of experimental data, specific features of heat transfer of boiling liquids in the thermosiphons, compared with the corresponding data for large-volume conditions, are revealed.

HP78 50023 HEAT PIPES FOR IMPROVING THE TEMPERATURE HOMOGENEITY IN FURNACES

Brost, O., Neuer, G., Brennst.-Waerme-Kraft, V 29:444-449, N11, Nov. 1977, In German

Heat pipes are outstandingly suitable to produce a homogeneous temperature distribution on surface and in hollow spaces. In particular, in the temperature range between 500 and 1100 C, many advantages can be obtained and maximum temperature differences of less than one K, even over large areas, can be maintained without difficulties. The article reports on the functioning, the production, as well as the operational behavior of the test samples. Some possible applications and examples of installations for high temperature furnaces are described.

HP78 50024 EXPERIMENTAL TEMPERATURE DISTRIBUTION AND HEAT LOAD CHARACTERISTICS OF ROTATING HEAT PIPES

Daniels, T.C., Willliams, R.J., (Univ. College of Swansea, Swansea, Wales), Int. J. Heat. Mass Transfer, V 21:193-201, N2, 8 refs, Feb. 1978

The capillary heat pipe, however, has a number of limitations such as the wicking limit, nucleate boiling, etc., and some of these limitations can be overcome in a rotating heat pipe. Experimental results show conclusively that the presence of a small quantity of a non-condensable gas (NCG) mixed with the working fluid has a considerable effect on the condensation process in a rotating heat pipe. The temperature distribution in the condenser shows the blanketing effect of the NCG and the ratio of the molecular weight of the working fluid to that of the NCG has a very definite effect on the shape of this distribution. Some of the effects are quite similar to the well-established data on stationary heat pipes.

HP78 50025 RELIABILITY OF LOW-COST LIQUID METAL HEAT PIPES

Ewell, G.J., Basiulis, A., Lamp, T.R., (Hughes Aircraft Co., Torrance, CA), 3rd Int. Heat Pipe Conf. Tech. Papers, Palo Alto, CA, p. 297-302, May 22-24, 1978, AIAA, Inc., New York, NY, A78-35617
Avail:AIAA

Low-cost stainless steel heat pipes containing sodium or potassium working fluids have been proven to have long-term reliability. Heat pipes fabricated from 304 stainless steel with wicks of the same material have exhibited over 10,000 hours of reliable operation at 600 C (potassium) and 700 C (sodium) in ambient environments. Temperature stability was maintained to within 5 C over the test period. Extensive metallurgical analyses of inner and outer surfaces of the heat pipes and of the wicks have shown only minor amounts of material transport and of leaching from inner surfaces. External oxidation was negligible and there were no indications of electrolytic corrosion. The depth of inner surface attack was only 0.001 to 0.003 cm in thickness after 10,000 hours of operation. From this information lifetimes in excess of 50,000 hours can be reliably predicted.

HP78 50026 A REACTIVE HEAT PIPE FOR COMBINED HEAT GENERATION AND TRANSPORT

Faeth, G.M., Groff, E.G., You, H.Z., Alstadt, R., (Pennsylvania State Univ., University Park, PA), Icenhower, D., (US Naval Material Command, David W. Taylor Naval Ship Research and Development Center, Annapolis, MD), 3rd Int. Heat Pipe Conf. Tech. Papers, Palo Alto, CA, p. 316-326, May 22-24, 1978, AIAA, Inc., New York, NY, A78-35620
Avail:AIAA

The operation of a reactive heat pipe for generating thermal energy from the reaction between molten alkali metals and halogenated gases, and transporting the energy to a load by heat pipe action is described. The present study was limited to the lithium-sulfurhexafluoride reactant combination. Experiments were conducted which demonstrated the operation of a reactive heat pipe at 1200 K, sustained heat fluxes in the range 0 to 300 kw/m^2, good fuel utilization for the reaction, and refueling procedures. Theoretical results are also described to illustrate aspects of system operation and limitations due to wick pumping capabilities; liquid displacement across the wick; and thermal resistances in the wick, the vapor transport system, and the condenser.

HP78 50027 EXPERIMENTS WITH GRAVITY ASSISTED HEAT PIPES WITH AND WITHOUT CIRCUMFERENTIAL GROOVES

Feldman, K.T.Jr, Munje, S., (Univ. of New Mexico, Albuquerque, NM), 3rd Int. Heat Pipe Conf. Tech. Papers, Palo Alto, CA, p. 15-20, May 22-24, 1978, AIAA, Inc., New York, NY, A78-35579
Avail:AIAA

The results of a series of experiments on performance of gravity-assisted heat pipes with and without circumferential grooves are reported. Heat transfer rates and temperature gradients were measured, so that heat pipe conductance and evaporator and condenser heat transfer coefficients were determined. Performance data is useful for determining the improved performance of grooved heat pipes compared to wickless heat pipes or thermosyphons and since the added cost of manufacturing the grooves is a significant part of the cost of the heat pipe, especially for long pipes. For a 91.4 cm long by 1.27 cm OD heat pipe with 40 grooves per cm, the maximum thermal conductance measured was 22.7 w/c, and the heat transfer coefficients in the evaporator and condenser were 5500 and 11,900 w/m^2 C. Experiments were also conducted on a y.4 m x 3.18 cm OD iron-water heat pipe without grooves and on a U-shaped copper water heat pipe with grooves.

HP78 50028 EXPERIMENTAL INVESTIGATION OF HEAT TRANSFER IN THE EVAPORATOR OF A WATER HEAT PIPE

Fillippov, Y.N., Inzhenerno-Fizicheskii Zhurnal, V 21:250-254, N5-6, 3 refs, May-June, 1977, Trans. in J. Engng. Physics, V 21:907-910, N5-6, Jan. 1978
No abstract available

HP78 50029 EXPERIMENTAL AND ANALYTICAL STUDY OF HEAT PIPE PERFORMANCE

Goryachko, I.C., Zhizhin, G.V., Heat Transfer Sov. Res., V 9:54-57, N2, 1 ref, March-April 1977

This paper presents measurements of temperature along a heat pipe and of the heat fluxes through it, carried by supersonic flow of sodium vapor. These test data are compared with results based on the one-dimensional steady-state theory of a nozzle discharging dry vapor.

HP78 50030 EVALUATION OF COMMERCIALLY AVAILABLE SPACECRAFT-TYPE HEAT PIPES

Kaufman, W.B., Tower, L.K., (NASA, Lewis, Cleveland, OH), 3rd Int. Heat Pipe Conf. Tech. Papers, Palo Alto, CA, p. 88-95, May 22-24, 1978, AIAA, Inc., New York, NY, A78-35590
Avail:AIAA

As part of an effort to develop reliable, cost-effective spacecraft thermal control heat pipes, Lewis Research Center of NASA is conducting life tests on 30 commercially available heat pipes in 10 groups of different design and material combinations. Materials are aluminum and stainless steel, and working fluids are methanol and ammonia. The formation of non-condensable gas is observed for times exceeding 11,000 hours. The heat transport capacities of the pipes are also determined. Considerable gas is found in two groups of methanol pipes; one group shows no gas. One group of ammonia pipes has no observable gas. Another group has much gas. Manufacturers' processing schedules are examined for differences explaining the presence of gas. Heat transport capacity is found to be severely reduced in some pipes containing gas.

HP78 50031 EXPERIMENTAL EVALUATION OF CRYOGENIC HEAT PIPES WITH VARIOUS HEAT CARRIERS AND CAPILLARY STRUCTURES

Kreeb, H., (Dornier System GMBH, Friedrichshafen, W. Germany), Molt, W., (Stuttgart Universitaet, Stuttgart, W. Germany), 3rd Int. Heat Pipe Conf. Tech. Papers, Palo Alto, CA, p. 203-210, May 22-24, 1978, AIAA, Inc., New York, NY, A78-35604
Avail:AIAA

No abstract available

HP78 50032 FABRICATION AND TEST OF A VARIABLE CONDUCTANCE HEAT PIPE

Lehtinen, A.M., (Rockwell Int. Corp., Downey, CA, Space Div.), NASA-CR-156712, NAS5-24171, Final Report, 78 p., 1978, N78-19443/8SL

A variable conductance heat pipe (VCHP) with feedback control was fabricated with a reservoir-condenser volume ratio of 10 and an axially grooved action section. Tests of the heat transport capability were greater than or equal to the analytical predictions for the no-gas case. When gas was added, the pipe performance degraded by 18 percent at zero tilt as was expected. The placement of the reservoir heater and the test fixture cooling fins are believed to have caused a superheated vapor condition in the reservoir. Erroneously high reservoir temperature indications resulted from this condition. The observed temperature gradients in the reservoir lend support to this theory. The net result was higher than predicted reservoir temperatures. Also, significant increases in minimum heat load resulted for controller set point temperatures higher than 0 C. At 30 C control within the tolerance band was maintained, but high reservoir heater power was required. Analyses showed that control is not possible for reasonably low reservoir heater power. This is supported by the observation of a significant reservoir heat leak through the condenser.

HP78 50033 AUGMENTING THE CONDENSER HEAT TRANSFER PERFORMANCE OF ROTATING HEAT PIPES

Marto, P.J., Wagenseil, L.L., (US Naval Postgraduate School, Monterey, CA), 3rd Int. Heat Pipe Conf. Tech. Papers, Palo Alto, CA, p. 147-154, May 22-24, 1978, AIAA, Inc., New York, NY, A78-35597
Avail:AIAA

A rotating heat pipe assembly was tested at rotational speeds of 700, 1400, and 2800 rpm using distilled water as the working fluid. Tests were made during film condensation on several copper condensers, including smooth-walled cylinders, an internally finned cylinder, and a truncated cone. The truncated cone surface was also promoted for drop-wise condensation using N-octadecyl mercaptan in octanoic acid. Heat transfer performance improved with increasing rotational speed. The internally finned cylinder and the truncated cone showed a 100 percent improvement over the equivalent smooth-walled cylinder. Dropwise condensation showed substantial improvement over film condensation, primarily at low rotational speeds.

HP78 50034 BREAKAWAY OF A LIQUID BY A GAS STREAM AT AN INTERFACE CONTAINING A GRID

Mateev, V.M., Filippov, Y.N., Dyuzhev, V.I., Okhapkin, E.V., J. Engng. Physics, V 33:1008-1012, N3, 3 refs, Sept. 1977

It is shown that in a system consisting of a gas stream, a liquid, and a grid, breakaway of a drop of liquid by the gas stream occurs when the bath under the grid is fully filled with liquid and both a positive pressure gradient and an excess of liquid are present. In addition, this paper determines the characteristic dimensions at which drop breakaway will begin for a given gas velocity.

HP78 50035 INVESTIGATION OF HYDRODYNAMIC CHARACTERISTICS OF HEAT PIPES

Melodiev, E.A., Manokhin, V.Y., Turbin, V.S., Izv. Vyssh. Uchebn. Zaved Mashinostr., p. 78-81, N10, 1977, In Russian

Results of an investigation of hydrodynamic characteristics of heat pipes with an inner downcoming loop and a separating insert at the condenser inlet are presented. Studies of the circulation in the pipe loop are conducted on glass models. It is found that a stable circulation in the loop is observed under annular conditions of flow of a two-phase stream of the heat carrier. By using the separation insert, the heat and mass transfer is intensified thanks to an increase in the rate of the flow and the multiplicity factor of the circulation.

HP78 50036 STUDY OF THE GAS DYNAMICS OF TURBULENT STEAM FLOW THROUGH HEAT PIPES

Mikhailov, V.S., Krapivin, A.M., Bystrov, P.I., Pokandiuk, G.I., (Dnepropetrovskii Institut Inzhenerov Zheleznodorozhnogo Transporta, Dnepropetrovsk, Ukrainian SSR), Inzhenerno-Fizicheskii Zhurnal, V 34:197-201, Feb. 1978, In Russian

The experiments described were carried out with a 26.5-mm-diam tube consisting of a non-permeable (adiabatic) section and two perforated sections, with blowing applied to the evaporation section and suction applied to the condensation section. The objective was to determine the combined influence of the three sections and to derive more accurate equations for the hydraulic design of heat pipe vapor channels. Data obtained for various section lengths over a wide range of Reynolds numbers showed that the gas dynamics of the flow in the evaporation and condensation sections depends on the radial Reynolds number, the relative section length, and the channel porosity. The data are diagrammed and analyzed.

HP78 50037 ELECTRON DRIFT VELOCITIES IN MERCURY, SODIUM, AND THALLIUM VAPORS

Nakamura, Y., Lucas, J., (Dept. of Electrical Engng. and Electronics, Univ. of Liverpool, Liverpool, England), J. Phys. D., GB, V 2:325-335, N3, 1978

A heat pipe drift tube has been developed for the first time and has been used to measure electron drift velocities in mercury, sodium, and thallium vapor. The drift velocity in mercury has been measured as a function of vapor pressure for $7 \cdot 10^{-18}$ + E/N + $1.4 \cdot 10^{-16}$ (units of V cm^2) and shows good agreement with McCutchen (1958). The drift velocities in sodium and thallium have been measured for the first time for $3 \cdot 10^{-17}$ + E/N + $5 \cdot 10^{-16}$ and $1.7 \cdot 10^{-17}$ + E/N + $3.9 \cdot 10^{-16}$, respectively. The sodium velocities show a pressure dependency attributed to the presence of dimers.

HP78 50038 PERFORMANCE EVALUATION OF GRAVITY-ASSISTED COPPER WATER HEAT PIPES WITH LIQUID OVERFILL

Nguyen, C.H., Abhat, A., (Stuttgart Universitaet, Stuttgart, W. Germany), 3rd Int. Heat Pipe Conf. Tech. Papers, Palo Alto, CA, p. 49-58, May 22-24, 1978, AIAA, Inc., New York, NY, A78-35584
Avail:AIAA

No abstract available

HP78 50039 TRANSIENT FLOW PHENOMENA OBSERVED IN HEAT PIPES

Oshima, K., (Univ. of Tokyo, Tokyo, Japan), 14th Int. Congress of Theoretical and Appl. Mech., Delft, Netherlands, 12 p., Aug. 30-Sept. 4, 1976, A78-14069

The flow field in heat pipes is discussed in terms of fluid dynamics, and experimental results are presented. Experiments were performed in wickless vertical heat pipes in which fixed amounts of air were introduced as a non-condensable gas. Water or a water-alcohol mixture was used as the working fluid, and temperature distributions along the condenser section and the pressure were measured. The effects of the introduction of a non-condensable gas are explained, and output signal data from hotwires placed in the heat pipes are presented.

HP78 50040 EXPERIMENTAL INVESTIGATION OF LAMINAR FLOW OF A LIQUID WITH A FREE SURFACE IN TRIANGULAR-SHAPED CHANNELS

Panevin, I.G., Smolin, M.G., Fluid Dynamics, V 12:142-144, N1, Jan.-Feb. 1977

At present, heat pipes are used in a number of heat engineering systems for removal and transfer of high heat fluxes. The magnitude of the heat flux transferred along the heat pipe in many respects is determined by the liquid flow rate in capillaries. In the present work, results are given of an experimental study of laminar liquid flow with a free surface in triangular-shaped channels with tangential frictional stress at the free surface. Experiments were carried out when the liquid flow in inclined triangular-shaped channels had Reynolds numbers of the approach air stream was $R = (1.6-3.6) \times 10^4$. The data are presented in relative coordinates as a dependence of the hydraulic resistance coefficient of the liquid on the tangential frictional stress at the free surface. It is shown that with an increase of the tangential frictional stress, the hydraulic resistance coefficient considerably increases.

HP78 50041 DETERIORATION IN HEAT PIPE PERFORMANCE WITH EXCESS WETTING FLUID

Srivasta, R.M., Varma, H.K., Sharma, R.C., (Mech. and Ind. Engng. Dept., Univ. of Roorkee, Roorkee, India), Letters in Heat and Mass Transfer, V 3:387-392, N5, 1976
Avail:TAC

An experimental investigation has been carried out to study the effect of the wetting fluid on the performance of an adiabatic heat pipe having water-cotton-wick matrix in a copper container. It has been found that when the wetting fluid charge increases beyond a certain limit, rapid decrease in the heat transfer rate occurs. For the heat pipe investigated, the limiting water content was about 2½ times the minimum required for the heat pipe performance. It is independent of the inclination of the heat pipe and the temperature difference between the evaporator and the condenser.

HP78 50042 HEAT PIPE PERFORMANCE CHARACTERISTICS WITH FLOATING SOURCE TEMPERATURE

Srivastava, R.M., Sharma, B.N., (Birla Inst. of Tech., Mesra, India), J. Inst. Engng., India, Mech. Engng. Div., V 59:226-228, MES, 3 refs, March 1978

This paper presents the operating characteristics of a heat pipe with a long adiabatic part. Cotton wick has been used as a matrix with water as the working fluid. The temperature of the heat source was varied while the temperature of the sink was held constant. It is concluded that (1) the rate of increase of heat transfer by a heat pipe, at higher mass flow rate of cooling water, is faster than the rate of increase of the temperature gradient; (2) the heat pipe would not cease to perform, at any inclination, provided there is a reasonable temperature gradient within the heat pipe.

HP78 50043 STUDY OF LIQUID METAL HEAT PIPES CHARACTERISTICS AT START-UP AND OPERATION UNDER GRAVITATION

Tolubinskii, V.I., Shevchuk, E.N., St mbrovskii, V.D., (Akademiia Nauk Ukrainskoi SSR, Institut Tekhnicheskoi Teplofiziki, K ev, Ukrainian SSR), 3rd Int. Heat Pipe Conf. Tech. Papers, Palo Alto, CA, p. 274-282, Ma 22-24, 1978, AIAA, Inc., New York, NY, A78-35614 Avail:AIAA

Temperature changes in liquid me al heat pumps (LMHP) are evaluated under conditions of both start-up and continuous operation. An analysis of dynamic characteristics is presented in three stages: (1) heat supply to start-up temperature, (2) establishment of sonic flow at the evaporator exit to the point at which the vapor flow along the entire LMHP length can be considered as a continuum, and (3) the point at which start-up temperature along the whole length becomes a stationary operating temperature. Attention is given to the effects of superheating and temperature pulsations throughout the system.

HP78 50044 INVESTIGATION OF GA S-CONTROLLED CRYOGENIC HEAT PIPES

Vasil'yev, L.L., Konev, S.V., uikov Heat and Mass Trans. Inst., USSR), Heat Transfer Sov. Res., V 9:58-60, N2, 1 ref, Mar h-April 1977

The performance of gas-con rolled cryogenic heat pipes was analyzed. Advantages of the use of a non-condensing gas in a cryogenic heat tube equipped with an additional reservoir are shown. Experimen al results for a liquid nitrogen heat pipe employing varying amounts of the working fluid are obtained.

HP78 50045 INVESTIGATION OF A CRYOGENIC THERMAL DIODE

Williams, R.J., (NASA, Ames, Moffett Field, CA), 3rd Int. Heat Pipe Conf. Tech. Papers, Palo Alto, CA, p. 177-183, May 22-24, 1978, AIAA, Inc., New York, NY, A78-35601 Avail:AIAA

This paper describes a series of parametric investigations to determine the effect of various fluid charges on the performance of a 0.635-cm-diam spiral-artery, liquid-trap diode in both the forward and reverse modes. Specific parameters such as forward and reverse-mode conductances, shutdown times and energies, and recovery to forward-mode operation are evaluated for ethane as a working fluid in the temperature range 170 K to 220 K. Results indicate that the heat pipe will not reliably start up in the forward mode. However, startup can be initiated when preceded by a diode reversal. Also concluded are data which show the susceptibility of the diode to fluid charge and tilt. The optimum fluid charge was found to be 2.67 g, and transport capability at this charge was in excess of 1200 w-cm at 200 K. The diode in the reverse mode exhibited a rapid shutdown (within nine min) with a shutdown energy of 1150 J (0.32 wh).

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00025	U.S. PATENT 4109709*

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